THE ROLE OF MARINE SCIENCES IN THE
MULTIPLE USES OF THE COASTAL ZONE OF
LAKE ERIE AND LAKE SUPERIOR

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THE ROLE OF MARINE SCIENCES IN THE MULTIPLE USES OF THE COASTAL ZONE OF LAKE ERIE AND LAKE SUPERIOR

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PART I

THE ROLE OF MARINE SCIENCE AND TECHNOLOGY IN THE USE OF THE COASTAL ZONE

Study Objectives

The National Council on Marine Resources and Engineering Development is developing a series of studies of the uses of the various types of coastal areas in the United States. The primary intent of these studies is to assess the effect which science and technology and institutional developments have had on the use of coastal zone resources and to determine the principles by which these measures may be strengthened to contribute even more to the effective utilization of capital, manpower, and natural resources in various coastal regions. These analyses will develop guidelines for marine research programs and other decision-making processes appropriate to the growing socio-economic activity along the nation's land-water boundaries.

As part of this effort, the National Planning Association under contract to the Marine Sciences Council conducted the current study of the use and management of the coastal zone resources of Lakes Erie and Lake Superior. The major objectives of the study are to:

- Review the background studies of factual data about the coastal zone resources of the two lakes, their utilization, and the economic and social ends served.
- Analyze the effectiveness of measures employed in the past for determining utilization of coastal zone resources including case studies of selected conflicts.
- Assess the potentials for applying marine science and technology to achieving greater multiple use, or more optimal use, of coastal zone resources.
- Identify and evaluate new or different measures to protect higher level utilization of coastal zone resources.
- Analyze international problems and opportunities in achieving optimal use of lake waters and lake-bed resources and recommend desirable new measures.

The Marine Sciences Council has used the term, coastal zone, with reference to "that area of the ocean affected by its proximity to the land and that area of the land affected by its proximity to the sea."[1] The National Commission on Marine Science, Engineering, and Resources for the purposes of the proposed coastal management system considers the coastal zone to include: "(1) seaward, the territorial sea of the United States and (2) landward, the tidal waters on the landward side of the low water mark along the coast, Great Lakes, port and harbor facilities, marine recreational areas, and industrial and commercial sites dependent upon the seas or the Great Lakes."[2] The Commission further suggests that the landward extent of the coastal zone be defined by each respective coastal state. In this regard, the Marine Sciences Council has defined the coastal zone in the Great Lakes Region as extending to the "interior limits of counties reflecting marine influence"[3], which for the most part includes the counties immediately adjacent to the Great Lakes, and also includes the entire surface of the lakes to the limit of U.S. jurisdiction.

For purposes of this study, the coastal zone of the Great Lakes has been viewed from two aspects. First, the overall planning study area has included the Great Lake Basin as defined by the drainage basin of the lakes. This is a convenient overall study reference point particularly due to the fact the Great Lakes Basin Commission has established a regional planning program on this basin -- as will be discussed later -- and because most of the drainage basin boundary is within 50 miles of the lakes' shoreline. This larger planning area definition was subject to flexible interpretation to allow consideration of broader regional factors influencing the various uses of the coastal zone. The second level of concentration -- and the most significant in terms of this study -- is the narrow band around the shoreline of Lake Erie and Lake Superior defined on the landward side by significant physical

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[1] Seminar - Multiple Use of the Coastal Zone, National Council on Marine Resources and Engineering Development, Williamsburg,Va., November 13-15, 1968, pp. 6-7.

[2] Our Nation and the Sea: A Plan for National Action, Report of the Commission on Marine Science,Engineering & Resources, Wash.,D.C., January 1969, p. 51.

[3] Marine Science Affairs, National Council on Marine Resources & Eng.Development, Washington, D.C. January 1969,pp. 6-7.

features or social and economic conditions that clearly delimit the direct marine-oriented activities. For statistical purposes, the counties and metropolitan areas adjacent to Lakes Erie and Superior were considered as part of the coastal zone; but otherwise, the narrower connotation was applied. For instance, super highways along the shoreline of Lake Erie falling only a few feet to several hundred yards from the shoreline have a "china wall" effect of dividing the hinterland from the coastline proper, virtually preventing marine-oriented activity from being established on the landward side. On the other hand, a high-rise apartment building in Buffalo or Detroit located some distance away from the shoreline but which commands high rents for the advantage of viewing the panorama of the lake and urban waterfront was not dismissed from being directly involved with the coastal zone environment.

Objectives for Optimum Use of the Coastal Zone of Lakes Erie and Superior

The term "optimum" use of the coastal zone implies a use characterized by the best or most favorable in terms of degree, condition, or amount of use. The terms "best" and "favorable" require a notion of values upon which to gauge the uses of coastal zone resources. These values are expressed in the form of goals and objectives, and which make the setting of these an important prerequisite step in planning for the optimum use of coastal resources.

Objectives for the optimum use of the coastal resources of Lakes Erie and Superior may be derived from three levels of interest:

(1) The national interest, in terms of the intent of Congress in declaring the policy and objectives for the development of marine resources through the Marine Resources and Engineering Development Act of 1966 (PL 89-454) and as further elucidated by the Marine Sciences Council and the National Commission on Marine Science, Engineering, and Resources for the development of the coastal zone.

(2) The overall development objectives of the Great Lakes Region, which under the terms of the Water Resources Planning Act and as expressed by the Great Lakes River Basin Commission, substantially overlap the maritime coastal zone.

(3) Specific objectives for potential new or expanded uses of coastal resources reflecting the above purposes and objectives, as may be identified by the present study.

A brief review of these levels of objectives is an appropriate introduction to stating the rationale and value judgments which are already a matter of official commitment and policy and as these reflect on the definition and interpretation of optimum use of the shoreline and waters of Lakes Erie and Superior. Furthermore, it is upon these higher order objectives that criteria and rationale will be developed to assess and give priority to alternative measures for achieving optimum use of coastal resources.

In a declaration of policy and objectives, the Marine Resources and Engineering Development Act of 1966 Congress espoused the following position:[1]

> SEC. 2. (a) It is hereby declared to be the policy of the United States to develop, encourage, and maintain a coordinated, comprehensive, and long-range national program in marine science for the benefit of mankind to assist in protection of health and property, enhancement of commerce, transportation, and national security, rehabilitation of our commercial fisheries, and increased utilization of these and other resources.
>
> (b) The marine science activities of the United States should be conducted so as to contribute to the following objectives:
>
> (1) The accelerated development of the resources of the marine environment.
>
> (2) The expansion of human knowledge of the marine environment.
>
> (3) The encouragement of private investment enterprise in exploration, technological development, marine commerce, and economic utilization of the resources of the marine environmen

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1 The Act specifically includes the water resources of the Great Lakes within the definition of "marine" resources.

(4) The preservation of the role of the United States as a leader in marine science and resource development.

(5) The advancement of educatinn and training in marine science.

(6) The development and improvement of the capabilities, performance, use, and efficiency of vehicles, equipment, and instruments for use in exploration, research, surveys, the recovery of resources, and the transmission of energy in the marine environment.

(7) The effective utilization of the scientific and engineering resources of the Nation, with close cooperation among all interested agencies, public and private, in order to avoid unnecessary duplication of effort, facilities, and equipment, or waste.

(8) The cooperation by the United States with other nations and groups of nations and international organizations in marine science activities when such cooperation is in the national interest.

While the Act provides the guidelines which a national marine science program should take; for the most part, it leaves to the Executive Branch those aspects of goal formation which delimit how far programs should be carried and which establish priorities in allocating national resources among various marine programs or between marine and other national programs.

Under the terms of the Act, two bodies were established: A National Commission on Marine Science, Engineering and Resources, and a National Council on Marine Resources and Engineering Development (Marine Sciences Council). The Commission on Marine Science, Engineering and Resources was established as an independent advisory body and given the mandate to: (1) determine the Nation's stake in the development, utilization, and preservation of our marine environment, (2) to review all current and contemplated marine activities and to assess their adequacy to achieve the national goals set forth in the Act, (3) to formulate a comprehensive long-term national program for marine affairs designed to meet present and future national needs in the most effective possible manner, and (4) to recommend a plan of government organization best adapted to the support of the program and to indicate the expected costs.[1]

The Commission has recommended to the President and to Congress a plan for national action and for orderly development of the uses of the sea, with a National Oceanic and Atmospheric Agency (NOAA) and strong national support of the establishment of state coastal zone authorities with primary responsibility to carry out specified national objectives for management of the coastal zone. Of particular importance to the Great Lakes, the Commission called for a Great Lakes Restoration Feasibility Test as one of a series of National Projects recommended for priority attention in stimulating and supporting the advance of marine science and technology and uses of the sea. The Commission recommended that NOAA launch such a National Project to explore the techniques of water quality restoration for the Great Lakes; and once feasibility has been established, the Federal Water Pollution Control Administration -- in cooperation with the International Joint Commission -- should assume responsibility for implementation.[2]

The Commission on Marine Science, Engineering and Resources in its report Our Nation and the Sea contains a comprehensive range of recommendations for management and use of the coastal zone. The Restoration Feasibility Test is mentioned here because of its significance toward identifying priority for improving the quality of water resources in the coastal zone and which,as will be discussed in Part III, is of particular importance to Lake Erie and,to a lesser extent, Lake Superior. Many other recommendations have relevance to the Great Lakes but which have not been reviewed individually in this report since these are adequately presented in the Commission Report and have common significance for Lakes Erie and Superior.

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1 Our Nation and the Sea, op. cit., p. vi.

2 Ibid., pp. 77-78.

The Marine Sciences Council acting as a cabinet level advisory body on the marine sciences to the President has endorsed the following general objectives for assisting in promoting the optimum use of the coastal zone:[1]

- Strengthen planning and decision-making processes that rely on the expertise and knowledge of the coastal states, including the Great Lakes states, and are responsible to national as well as local needs.
- Expand the structure for consideration of multi-state issues in coastal zone planning and management.
- Broaden Federal policies and programs -- without supplanting state autonomy and responsibility -- to encourage the states to develop and carry out programs of planned use of the coastal zone in the national interest.
- Develop new mechanisms for acuqiring, analyzing, and distributing management information and environmental data concerning the coastal zone.

More specifically (but on a national scale), the Council has recommended that the concerned Federal agencies take further steps in six areas to carry out the above policy intensions for optimum use of the coastal zone:[2]

(1) Strengthening policy planning, coordination, and development by defining the national interest in the coastal zone more clearly and encouraging enunciation of national goals and objectives in coastal zone development by both the Executive and Legislative Branches; strengthening coordination of Federal agencies in the review of proposed coastal zone alterations; broadening studies of factors that influence land development in the coastal zone, possibly by a multi-disciplinary panel of specialists on coastal zone development available for consultation with the states; and filling present planning gaps for making mass coastal recreation available near large congested coastal areas and identifying policy gaps in harbor waterfront restoration.

(2) Resolving legal and other questions related to coastal zone property, boundaries, and use by clarifying the effect of man-made offshore structures on Federal-state boundaries; accelerating the delineation of domestic submerged land boundaries; and continuing efforts to minimize coastal interference between defense and other uses.

(3) Assisting commercial and sport fisheries by examining the adequacy of laws governing commercial fishing between the seaward boundaries of the states and the limits of national jurisdiction; developing a model, scientifically based state law governing commercial fishing activity for

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1 <u>Marine Science Affairs</u>, January 1969, p. 74.

2 <u>Marine Science Affairs</u>, <u>Ibid.</u>, pp. 74-76.

consideration by the states in meetin g problems unintentionally induced by archaic conservation measures; and developing a better system for collecting, processing, and disseminating statistics on commercial and sport fishing.

(4) Enhancing recreational and other uses of the coastal zone by assisting the states in developing model legislation on coastal zoning; promptly identifying high-value coastal areas essential for public use and considering a moratorium on disposal of "surplus" Federal land in the coastal zone; and seeking legislation to expand beach erosion and hurricane protection programs.

(5) Maintaining the quality of coastal waters by enforcing water quality standards and other relevant laws to prevent further degradation of coastal waters; controlling ship-induced pollution in harbors and coastal waters; accelerating research to determine the significance and duration of the effects of major oil spills on marine animals and recreation; and devoting increased attention to reducing pollution from insecticides, herbicides, and fertilizers.

(6) Encouraging research, education, and information development and dissemination by establishing coastal preserves for ecological research; establishing a central data bank for information and scientific data on coastal zone activities and conditions; encouraging training of coastal zone planners and managers under the Sea Grant Program; evaluating the need for a National Institute of Coastal Zone Studies; preparing a handbook to serve as a guide for local coastal zone development; developing information and legislation on preserving public access to the coast; and encouraging expanded research programs to quantify environmental effects of estuarine and coastal pollution.

The Marine Sciences Council has also recognized the importance of state governgovernments being the focal points for planning and managing activities in the coastal zone with the Federal and local governments supporting the states in carrying out this responsibility.[1]

The Great Lakes provides the most forceful example of the interstate character of a coastal zone region. In the Great Lakes Basin, cooperative mechanisms for coordination of activities within the coastal zone are found in various forms of regional organization which are discussed later in this section. It is in these activities in the coastal zone that the Marine Sciences Council views marine science

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[1] Marine Science Affairs, 1969, p. 74.

and technology as tools to assist in accomplishing the above explicit goals and tasks predicting possible inadvertent harmful effects of coastal zone uses, reducing construction costs so as to add to the range of choices for optimum use(s) and programs and in evaluating costs and benefits to facilitate the task of making choices for these uses and programs.[1]

In the present study, attention will be focused on delineating policy issues and activities for optimum use of the coastal zone with special concern for marine science affairs or developmental objectives that are particularly germaine to the coastal zone resources of Lakes Erie and Superior and the institutional problems in optimizing their use. It should be added that concentrating the study on these two lakes provides an economy of effort versus a similar study involving all five of the Great Lakes. It also provides the widest range of conditions or coastal zone resource problems. Lake Erie is the most polluted , densely populated, and industrialized of all the five lakes within the coastal zone region; whereas, Lake Superior -- with a few important exceptions -- is the least polluted and least developed of all the five lakes within the coastal zone region.

A Review of Institutions and Measures

A host of public agencies have various interests and activities in the Great Lakes Region ranging from direct operational responsibilities in the region of the lakes proper to a somewhat casual interest in Great Lakes affairs.[2] A large majority of the cities and unincorporated urban areas situated along the U.S. shoreline of Lakes Erie and Superior have been visited during a field trip by the authors in preparation for this study. It should be noted that most of the larger cities and

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1 Marine Science Affairs, March 1968, p. 63.

2 A parallel study activity of the Marine Sciences Council currently in progress is that of developing a compendium of these institutions including brief descriptions of their responsibilities, authorities, interests, and addresses.

counties have agencies dealing with planning, public works, port and harbor development and operation, and waste management and water treatment plants. It is highly important that local jurisdictions be considered in evaluating requirements for coordination with state, regional, and national development programs and in a more meaningful definition of objectives and programs for an optimal use of the coastal zone of the Great Lakes. To this end, officials of a number of city and county agencies were interviewed, and much valuable information and useful insights were obtained. See where this [illegible]

In addition to public agencies, there is a wide variety of <u>private nonprofit</u>, <u>professional</u>, and <u>special-interest organizations</u> which have an interest in the use and management of the resources of the Great Lakes Region. The interest of some of these organizations may be limited to more or less sporadic attention as when a professional society conducts a symposium or publishes journal articles concerning the application of its discipline to Great Lakes problems. Still other organizations may be directly involved in Great Lakes affairs on a continuing and concerted basis. Among these is the Great Lakes Foundation which is concerned with basic research in the Great Lakes and closely monitors such activities and cooperates with both industry and government in encouraging research in areas felt to be covered inadequately. A third group of organizations includes the National Association of Counties, National League of Cities, and Council of State Governments and is likely to be interested in the evolution of institutional arrangements in the Great Lakes Region which affects their representative interests from a national viewpoint. The American Institute of Planners, the Council of State Planning Agencies, and the American Institute of Public Administration might likewise be interested in the measures which affect the planning and decision-making process.

Even though the list of such organizations approaches excessive length, it would indeed be a more difficult task to discern from the vast number of conservation, scientific, and professional organizations in the United States and Canada the ones that would have no interest in, or contribution to make to, the effective utilization of the coastal resources of the Great Lakes. A few agencies have been selected for analysis to determine how they might best be used in developing and implementing institutional and technological measures.

Two examples may be cited which suggest some of the implications which may be expected to emerge from analyzing the roles of these private organizations. The joint sponsoring of the Great Lakes Water Resources Conference in Toronto, Canada, in June 1968 by the American Society of Civil Engineers and the Engineering Institute of Canada is an excellent example where ideas and information may be exchanged without the "program" or "institutional" constraints sometimes encountered in formal operating procedures of government and industry. Such conferences provide a vehicle for the exploration of problems and opportunities and the expression of opinions or recommendations for action from a professional viewpoint -- that is, as much as possible without the interest biases of the aforementioned programs and institutions. For instance, in the proceedings of this conference, a series of recommendations were presented calling for a comprehensive plan for the staged development of the water resources of the Great Lakes and related land uses, including the establishment of understandable goals, a viable character in the face of changing socio-economic requirements and improving technology and other fundamental bases which too often are overlooked in the fanfare of announcing new organizations and schemes.[1]

A second example involves special interest groups which play a particularly

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1 MacLaren, J.W.; and Clevenger, R.F., "New Requirements in Water Resources Planning on the Great Lakes", Proceedings of the Great Lakes Water Resources Conference, The Engineering Institute of Canada, and the American Society of Civil Engineers, Toronto, Canada (June 24-26, 1968). pp. 376-377.

important role in organizing the expression of their position in response to the challenge of competitive uses of resources. The commercial and sport fishing interest is an example of groups which air similar policy positions for their respective industries in the battle against pollution, but frequently take opposite positions with respect to fishery management. This example also demonstrates the placement of different relative emphases between the applications of science and technology and institutional arrangements in developing ways and means to reach solutions to problems. The ability to solve problems of bio-degradation by pollution will depend a great deal on the development of new technology to bring the task of pollution abatement within achievable ranges. Anti-pollution technology may be necessary but not sufficient; in which case, strong institutional forces may be required to implement the new technology. The reconciliation of fisheries management issues between commercial and sport uses may require initial emphasis on institutional arrangements, such as those reflecting certain economic and political conditions. The latter may still require scientific information as a basis for judgment as well as the development of special technologies for unique management or harvesting practices; however, the problem-solving process in this case gives major emphasis to the institutional arrangements involved.

In sum, it is important to consider <u>both institutional and technical aspects in developing strategies for problem-solving measures</u>.

As might be expected, the various academic institutions engaged in Great Lakes research activities concentrate almost entirely on the physical sciences. Although there are some related studies, such as recreation, land and water use inventories, economic analysis associated with a particular development program, the excellent research capabilities of the Great Lakes colleges and universities in the social sciences including economics, business management, law, political science, planning, and architecture appear to be underutilized in the planning studies related to the coastal zone resources of nearby regions. Research in social science subjects could provide an essential and valuable contribution to exploring institutional and techno-sociological implications of measures for optimum use of resources of the coastal zone. The National Sea Grant Program provides an excellent means of eliciting and strengthening social sciences in marine science affairs in the Great Lakes as well as other coastal regions.

Academic institutions in the Great Lakes Region will continue to play an important role in meeting the manpower training and educational requirements for the continuing growth of the region. Steps to provide the incentive and assistance to colleges and universities to conduct research in the physical and social sciences and to fulfill the educational requirements related to regional growth factors associated with marine science and technology would be an important part of institutional arrangements designed to encourage the optimum use of the coastal zone.

Unlike the lengthy coastal regions along the Atlantic, Gulf, and Pacific Coast states, the Great Lakes Region has long been identified as a contiguous geographic unit. Problems and potentials for development in this Great Lakes Region have common aspects which have stimulated regional approaches to solution and exploitation by various institutions through the Great Lakes states. A review of the research, planning, and management activities of certain <u>regional agencies</u> would provide the broadest insight into the use of human, capital, and physical resources and into the activities of Federal, state, and local agencies. Additionally, regional agencies for the most part have an objective for establishing a framework for coordinating with the agencies of the different levels of government which have interests and activities directly or indirectly related to their purpose. Of the many governmental agencies at the Federal, state, and local levels which recognize certain commo regional interests, three organizations, in particular, stand out as having broad and substantial responsibilities for dealing with regional development and resource management problems in the U.S. portion of the Great Lakes Basin. For the above-stated reasons, the Great Lakes Basin Commission, the Upper Great Lakes Regional Commission, and the Great Lakes Compact Commission have been selected for review. There are also other important regional bodies, such as the Great Lakes Fisheries Commission and the International Joint Commission, which have been established to resolve certain specific regional problems of an international nature.

The main problem associated with a "regional approach", particularly in the Great Lakes area, is that the present political jurisdictions of local and state governments are not organized in size or boundary configurations to deal effectively with common economic and physical problems. Indeed, if one considers the largest region of the Great Lakes as being defined by a common water drainage basin, it is obvious that economic, industrial, climatic, and demographic considerations would yield a number of subregions of varying sizes and configurations. Therefore, states, local governments, and Federal agencies are finding it necessary to re-structure or re-orient their particular functional responsibilities along regional lines which transcend existing jurisdictional boundaries. This broader outlook is requiring the development and initiation of regional governmental institutions in order to plan and execute programs. In this regard, the three above-mentioned U.S. regional agencies have in common comprehensive planning mandates, advisory authority, and active programs in promoting cooperative solutions to regional problems, including those of the coastal zone but not limited thereto.

Although the scope of these regional agencies is comprehensive in nature, the main distinguishing characteristic of their respective activities lies in the purposes underlying the mandates by which they were established. The Great Lakes

Compact Commission was the first of these to be established (1955) and reflects the interest of the state governments around the Great Lakes to reconcile conflicts and cooperate with their common interests in the use of water and related land resources of the region. The Great Lakes Basin Commission was created in 1967 under Federal mandate to enable state and Federal agencies to plan for the cooperative use of the water resources in the Great Lakes Region. The Upper Great Lakes Regional Commission was also established in 1967 under Federal mandate to attack some of the problems associated with the economic lag of the northern portions of the region, of which water resources is one aspect of the problem.

The main authority or ability of these three U.S. regional agencies to control, or otherwise affect, the use of resources in the Great Lakes Region lies solely in their ability to influence the activities of the participating agencies and jurisdictions which have planning and management authority over the use and development of resources within their respective areas. This influence is primarily exerted through the coordination of planning and study activities and through the effect of regional recommendations on the respective actions and budget processes of the cooperating-participating agencies in these regional organizations. The emphasis on technical and financial assistance rendered by these regional organizations has relatively limited influence on the activities of the participating agencies, particularly towards regional objectives identified by the regional agency. This suggests the need for a strengthened role of a Federal agency dealing primarily with marine science affairs or programs.

The two international organizations -- the International Joint Commission (1909) and the Great Lakes Fisheries Commission (1955) -- were established jointly by the United States and Canadian Governments to deal with the use and management of water-related resources which exist in a state of dynamic flux across the boundary between the two nations. The IJC has the authority to review and approve any structure or use of water which affects the flow of water across the U.S.-Canadian boundary. The Great Lakes Fisheries Commission was established to develop recommendations to enhance the fishery resources of the Great Lakes common to the United States and Canada, and to develop and execute specific measures to attack the lamprey eel problem which began with the opening of the Welland Ship Canal and which had a serious toll on major commercial and sport fisheries of the Great Lakes.

The most significant aspect of the IJC and the Great Lakes Fisheries Commission is that they were established to handle regional problems in the Great Lakes that have international implications; namely, water and fishery resources. Through the involvement of the IJC in pollution problems, the scope of interest has since broadened to include both air and water pollution, thus covering the spectrum of land-air-water resources problems in the basin common to the United States and Canada

The Great Lakes Basin Commission was formed under the provisions of the Water Resources Planning Act of 1965. The primary job of this Commission is to develop a comprehensive plan for the joint development of water and related land resources in the Great Lakes Basin. This primary mandate surplants the earlier river basin planning responsibilities of the U.S. Army Corps of Engineers -- although, to be sure, the project studies and activities of the Corps still have a very important bearing on water resource developments in the Great Lakes Basin. The Basin Commission is made up of appointed representatives from the affected states and Federal agencies with functional responsibilities in the region. The Commission is purely advisory in nature and is especially concerned with planning matters. The Great Lakes Basin Commission staff activities are supported through the budgets of the respective participati

[1] An important part of water use and management problems under investigation by the IJC is the effects of water on the use of related land resources.

agencies. The outstanding characteristic of the Basin Commission's operations is that the joint planning program conducted under the "auspices" or coordinating direction of the Basin Commission is presented to the Federal Water Resource Council, and thence, to the Bureau of the Budget, in its entirety. That is to say, the joint planning program is subject to review by the Council and the Bureau of the Budget on a complete planning program basis. As will be discussed later with the other two regional agencies, the budgets for the component studies of the participating agencies in the regional planning program are carried forth by each respective agency through its own review process. Sometimes, the broader program implications of specific studies may not adequately be represented in separate budget processes.

The first stage of the regional joint plan by the Basin Commission is presently under preparation. This first stage is called the "Comprehensive Framework Studies", for which final review and approval for initiation is anticipated by November of this year. The Framework Study elements presently involve existing study activities of the cooperating Federal and State agencies. Indeed, there has been a great need to bring together the many functional research and planning activities presently in operation in the Great Lakes Region under one roof to improve the exchange of information and to coordinate planning efforts.

Many of the participating agencies in the Framework Studies have already set up operational goals and targets toward which they are working as a part of their regular operations. In this regard, the "bottom-up" approach to the Great Lakes Basin Commission's planning process appears to cover the main problems of resource use and management. However, in view of the extreme complexity of the comprehensive planning process itself, there will surely emerge gaps and interrelationships of Great Lakes problems during the course of the Framework Studies that have not been adequately anticipated or accommodated in planning research efforts. In this latter regard, for instance, in reviewing the tentative draft, one does not develop the feeling that the preparation of the Framework Studies and the joint comprehensive plan is being based on a strong statement of direction (in the sense of goals, objectives, or targets) for regional growth and development, nor that the Commission -- at least in its early efforts -- is preparing the sort of goal definitions or the setting of targets that would be useful to the Bureau of the Budget in assessing regional program priorities on a national basis, or to the Marine Sciences Council for determining the emphasis needed in developing new marine science and technology which could help solve the region's problems.

The avoidance of such quantitative goal-setting is most likely a means of covering up or avoiding reconciliation of differences in jurisdictional interests; but, by the same token, this detracts from developing a more optimum development of coastal zone resources from an overall regional standpoint. The accomplishment of the presently defined Framework Studies will be dependent upon the authorization and appropriation of funds by Congress (as well as the state legislatures involved), and having the staff and consulting manpower to execute the programs once they have been funded. This could provide a useful tool for redressing any gross distortions in achieving a more optimal regional development. Another important problem is the scarcity of qualified planners and researchers in the conduct of many studies by institutions contributing to pre-planning information and analyses in the Great Lakes area.

It should be noted that the Great Lakes Basin Commission has the usual growing pains of a new agency, but is nevertheless achieving substantial progress in preparing a gigantic comprehensive joint regional planning program. In seeking cooperation in the regional affairs of affected agencies and jurisdictions -- and upon which the execution of the planning program is dependent -- the Commission will obviously need to exercise caution in avoiding the appearance of invading the existing powers of Federal agencies or state and local jurisdictions, even though a comprehensive planning mandate exists to provide the necessary regional development policy guidelines. This means that although clearly stated regional goals and objectives should emerge from, and be stressed by, the planning program, the Great Lakes Basin Commission or any of the other advisory regional agencies should not be forced into -- or be too quickly criticized for assuming limited posture with respect to -- developing implementation and control measures (as per the feelings of strong advocates of regional government). The idea of comprehensive planning as a regional function is yet young and, therefore, is subject to a serious setback if measures to establish and enforce regional control are prematurely introduced.[1]

As will be discussed below with respect to the Great Lakes Compact Commission and the International Joint Commission, the needs for regional control measures traditionally emerge on an individual basis responding to specific requirements. At a later time, the need to "coordinate" control measures may become recognized, as is happening with the region's planning activities. Furthermore, it does not necessaril follow that the "comprehensive planning agency" should automatically be the "plan implementation" or "control" agency, nor is there a definite role that the comprehensive plan itself should play. Some planning authorities, for example, believe the plan should be an overall unofficial policy and information guideline which is kept up to date for the benefit of all types of decision-makers. Others believe the plan and the official master plan for development should be adopted and followed as precisely as possible, allowing for flexibility and periodic revision and updating. Hopefully, the most workable strategy for the role of the Great Lakes Basin Commissio

1 The Water Resources Planning Act of 1965, under which the Graat Lakes Basin Commission was established, specifically states that the Commission's actions shall not be construed to pre-empt the responsibilities or authorities of existing agencies in the region.

joint comprehensive planning program will be developed from the study process itself as well as from insight into the institutional arrangements through which the plans may be utilized.

Another important factor to be considered in analyzing the scope of the Framework Studies is concerned with the extent to which the Great Lakes Basin Commission (or any of the advisory regional agencies) can: (1) influence or modify the direction of the ongoing cooperative studies, or (2) encourage the undertaking of studies to cover gaps (overlaps that do exist may be politically unavoidable) in constructing and administering a comprehensive joint planning program. This is primarily a function of the willingness of the participating agencies. In other words, the success or effectiveness of the Great Lakes Basin Commission at this early stage in developing a comprehensive planning process, as well as a plan, for the region will depend more upon the aggregate intentions of the policy decision-making leadership of the participating agencies to express their regional interests through the vehicle of the Commission than upon the exercise of the planning authority of the Commission and its staff. This relationship is clarified in order to give the proper prespective to assessing present and future accomplishments of the Commission and Federal, state, and local agencies in solving regional problems. To the extent that the Commission's planning activities have been reviewed, it appears that the cooperation and contributions of the participating agencies -- as demonstrated in the tentative Framework Study draft -- is a well-organized and fairly complete set of activities.

While the present organization of the Commission's joint planning program is based geographically on the subregions of the Great Lakes' drainage basins and on functional (problem-oreinted) headings, neither these dimensions nor subregions geographically or functionally lend to the identification of the "coastal zone" as a regional unit for study purposes. Although for the purposes of this study the Marine

Sciences Council considers the entire drainage basin and waters of the Great Lakes as within the framework of planning for the coastal zone, the relationship between the "intense, varied human uses superimposed" on the "intricate, delicate ecology" of the land-air-water interface along the perimeter of the Great Lakes is not described as an element of special study commensurate with the elements of the Commission's planning program.

One might also have defined the coastal zone in terms of a more or less indeterminate narrow band on either side of the shoreline as having special importance in evaluating the commonality or conflict of interests with regard to multiple uses of the marine resources of the "coastal zone". A focused identification of this more restricted coastal zone would also provide criteria for comparision of interests of overlapping basin-wide jurisdictions of the marine-related zone with those having problems and interests more peculiar to the hinterland of the drainage basin area. This problem of zonal differentiation also applies to other regional jurisdictions extending beyond the drainage basin, as for instance, the Upper Great Lakes Regional Commission whose jurisdiction based upon economic criteria includes many counties (in Minnesota and Wisconsin) outside the Great Lakes Drainage Basin but which are linked with coastal zone counties by certain common economic problems not particularl involved with coastal zone resources.

Other study efforts of the Marine Sciences Council are dedicated to defining in precise terms the criteria by which the coastal zone may be defined. The problem of defining this regional unit is particularly difficult in the Great Lakes Region. The configuration of a regional boundary will conform to the particular function or problematic feature being described geographically. For this reason, considerable difficulty is frequently encountered when trying to define a single regional boundary to include a variety of geographic, social, or other "problem" commonalities. This task is particularly difficult in the coastal zone because of the great variety of factors and characteristics such as uses, political boundaries, physical features, and ecological conditions which should be included within the definitional criteria -- and for which variety is even more extreme in the Great Lakes Region. Still, however, it seems obvious from visually appraising the coastal zone that the primary zone of common influence is concentrated largely within the few hundred feet or yards of shoreline and water-oriented uses and extending, at the most, to the interior boundary of the tier of counties and contiguous urban areas adjacent to the lakes. In many areas (and especially along the U.S. shorelines of Lakes Erie and Superior), a dominant natural or man-made feature exists which demarks the orientation of man's activities either toward the shoreline and lake waters or to the hinterland. These are such things as freeways closely paralleling the shoreline or a waterfront area of a city which is separated from the central business district by a main traffic artery, railroad, or bluff -- as in the case of Erie, Pennsylvania. Of course, there are certain very broad geographical influences affecting the coastal zone in common with hinterland areas such as weather and climate factors, drainage basin features, shared economic and social conditions which may require broad regional program planning to preserve shoreline resources or enlarge their beneficial use. This is why despite the importance of focusing on the relatively narrow perimeter of the coastal zone in this study, it is also important to take a broader view of regional development such as that encompassed by the Great Lakes Basin Commission. Another important agency having broad regional jurisdiction is that of the Upper Great Lakes Regional Commission which was established under the provisions of the Public Works and Economic Development Act of 1965. The Commission was formed to stimulate the economic development of the northern portions of Minnesota, Michigan, and Wisconsin of the Great Lakes Region which have significantly lagged the nation in economic growth and prosperity. The primary purpose of the Regional Commission is to develop a broad long-range, economic development plan for the designated region, and to provide technical and financial assistance in planning and development activities of participating state and local jurisdictions enabling these jurisdictions to provide maximum matching funds for participation in other Federal grants-in-aid programs which will be of economic benefit to the region. The Upper Great Lakes Regional Commission differs from the Great Lakes Basin Commission and the Great Lakes Compact Commission from the standpoint that the Regional Commission's scope is limited geographically to the more economically depressed area of the Great Lakes Region and, hence, its planning mandate is of a broader economic development scope.

In this latter connection, the Regional Commission has certain advantages that the other Commissions do not have. The Regional Commission can plan for all function areas of resource and economic development such as transportation, education, and water development including the roles of local government and private industry. Also the economic development objective lends itself to better interpretation and priority assessment of various regional development activities. For example, since the main goal is to achieve greater economic development, research proposals, development projects, and other studies have a clear mandate for developing their jurisdiction.

Unless a proposal can be justified on the basis of its contribution to regional economic development, such as increasing employment or productivity, it is not approved. Such straightforward criteria are not so clearly apparent in the review processes of the other Commissions.

The most significant characteristic of the Upper Great Lakes Regional Commission is the fact that the representatives of the participating states within the economic development region are the chief executives of the states -- the governors. The federal representative, who acts as co-chairman of the Regional Commission, is appointed by the President. Although the recommendations and actions of the Regional Commission are advisory, as are the other Commissions, the fact that the commissioners are themselves key decision-makers in their respective states holds considerable advantages in promoting follow-up action by the state governments.

Another advantage of the Upper Great Lakes Regional Commission is the availability of supplemental technical and financial assistance to aid a wide variety of public and private entities in developing projects. Each assistance project becomes an implementation tool or measure to accomplish the economic objectives for regional growth established by the Commission, with the additional advantage of being able to extend such assistance (with the approval of the Commission) directly to private parties for commercial and industrial projects as well as public works projects or services, such as sewer facilities or education and training.

The Upper Great Lakes Regional Commission area of scope covers only the western portion of the Great Lakes Basin Commission's jurisdiction (while extending beyond the Great Lakes Basin to the South and West).

However, both of these Commissions rely heavily upon the contributions of federal and state agencies cooperatively participating in their planning programs. As discussed in the preceding section, the Great Lakes Commission has initiated a framework study program as the first stage leading to the preparation of a comprehensive joint plan for the use of water and related land resources of the Great Lakes Basin. The Upper Great Lakes Regional Commission has a similar mandate to develop a comprehensive plan for the economic development of its region. As the Regional Commission's legislative mandate stressed action, the Regional Commission went directly into a first-stage program to review the studies, planning activities, and project proposals that have already been accomplished throughout the Region. On the basis of these previous study efforts, an "inventory of needs" was developed from which a list of urgent projects was selected. These projects were based on criteria designed to spur rational development and are listed in the Appendix (pp..16-18).

The Regional Commission has organized these urgent programs into an "Early Action Program". This Program has the advantage of the governor's approval, which facilitates a particular state agency's project contribution receiving adequate attention in the state's budget process. However, the same sort of advantage is lacking with regard to the various federal agencies with responsibility to carry forth project components of the Early Action Program through their budget processes. Even though the Early Action Program may have the endorsement of the Regional Commission and the Secretary of Commerce, it does not have the advantage, as does the Great Lakes Basin Commission, of being able to carry forth its framework study package through one budget process, as in the spirit of PPBS.[1]

As a part of the Regional Commission's economic development program, a

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[1] Planning, Programming, Budgeting System

comprehensive long-range economic plan for the region will be formulated. It is the coordination of the longer range regional planning effort between the Regional Commission and the Great Lakes Basin Commission that is important. The problems of the Great Lakes Region are so broad and complex that the Early Action Program and the Framework Studies are surely needed as foundations for setting the stage for longer range planning as well as coordinating on-going activities toward immediate problem-solving steps in critical areas of the region. It is imperative -- both in terms of national and regional interests -- that the longer range planning programs for economic development and water-related land resource development be based on the same proposed or established goals for the region as a whole.

Inquiries into this aspect of coordination indicate that, as the planning programs of both of these agencies are yet relatively new, more time will be needed to achieve a higher degree of coordination. Moreover, it is important that this be done before these two programs advance in certain directions which will make reconciliation of programs and objectives more difficult to achieve with regard to polar influences of subregional or local positions. A closer review of these planning programs would perhaps reveal some of the latter influences already; but if given the benefit of clearly identified long-range objectives, shorter range programs of localized action enacted to pressure points within region-wide problems will have the opportunity to gradually give way or grow into the proper scale and perspective.

The same observation made earlier with respect to the inadequate treatment of the coastal zone[1] in the Great Lakes Basin Commission studies, may be made

[1] Henceforth in this report, we shall use the more restricted interpretation of the width of the Coastal Zone as being much less than the width of the drainage basin of the Great Lakes.

about the Early Action Program. For example, the National Sea Grant Program could contribute to the training of researchers and technicians to assist in the development of coastal zone resources if the problems, needs, and opportunities of such development -- particularly those relating to the "marine sciences" -- were properly identified and articulated in the Early Action Program and Framework Studies. The financial assistance provided to the State of Minnesota by the Regional Commission to enable that state to obtain matching funds from the Bureau of Commercial Fisheries for the propagation of Coho salmon in Lake Superior is an excellent example of the cooepation between economic development and resource management agencies and programs.

Yet, the relationship for stimulating economic activity is not always so clearly demonstrable in the coastal zone. For example, two of the four economic development projects that received assistance along the Lake Superior shoreline involved the increase of boat facilities at Saxon Harbor, Wisconsin; and Grand Marais, Minnesota. On the other hand, the NPA staff in interviewing a local planning official in the area obtained a picture of a recreational boating potential that was not developed in this general vicinity because of the lack of adequate maps and charts, and the provision of current weather information and safety facilities such as harbors of refuge. These are typical public services which would encourage the increase of boating activity along the relatively uninhabited shoreline of Lake Superior, rather than the focus of activity on just a few small harbors or marine facilities. However, the resulting increase in total employment and economic benefits may be more easily measurable in harbor developments than the more widely diffuesed services just mentioned which may ultimately involve a greater increase in economic activity throughout the coastal region. This example shows the kind of information and expertise that may be contributed to the Early Action

Program activities by strengthening the study aspects dealing specifically with the coastal zone as an economic unit.

Another problem in this regard is associated with assessing economic problems in the coastal zone. The problem of underutilization of manpower, capital, and natural resources along the shoreline of the coastal zone, particularly with regard to those resources and activities that are "water-orientated", is typically widely dispersed. For example, because of the heterogenous nature of the fishing industry and the spread of fishing vessels to a great number of home ports, seldom does the number of unemployed fishermen show up as a significant figure in regular labor force reporting practices. Yet at the same time the industry as a whole is known to be relatively depressed in the Great Lakes Region. The previously mentioned boating example is also appropriate to this characteristic of economic conditions along the shoreline of the coastal zone. For this reason, it would be desirable for such a regional planning agency to treat the coastal zone as an economic sub-unit and organize employment data and other information pertaining to "shoreline-orientated" activities for the purpose of comparing specific coastal zone location needs with other subregional unit needs.

Still another regional agency is the Great Lakes Compact Commission. This is an advisory body established by compact of the Great Lakes states in 1955 for the purpose of meeting water resource responsibilities in the Great Lakes Basin by cooperative state and interstate action.[1] In ratifying the Great Lakes Basin Compact, the states designated the Great Lakes Compact Commission as their joint research and advisory agency on Great Lakes water resources development, programs, and problems. The lake basin scope of the Compact Commission is similar to the Great Lakes Basin Commission scope, as well as being similar in water resource

[1] In 1968, Congress ratified the Great Lakes Basin Compact with the enactment of P.L. 90-419.

orientation. However, the planning and study activities of the agencies participating in the Compact Commission activities are more management and implementation -orientated due to the nature of the Compact commitment.

The members of the Compact Commission are appointed by the governors or as specified by the laws of the membership states. Most of the members are the heads of natural resource departments, and a few are members of state legislatures. The activities of the Compact Commission are financed solely with state funds, and the recommendations of the Commission are purely advisory. A significant activity of the Compact Commission at this time is the development and presenting of a management compact to the respective participating states and federal agencies involved in the Great Lakes Region. This management compact is being designed to facilitate the coordination of resource management activities of these agencies which have region-wide implications.

The role of the Great Lakes Compact Commission has been to assist the eight states within the Great Lakes Basin to discharge their responsibilities for the development and protection of the water resources of the lakes, particularly with respect to region-wide matters of common interest and concern to the states. The Compact Commission's activities have primarily been concerned with water levels, water quality and pollution control, fisheries, and commerce and navigation. For example, in the 1965-66 period, the Compact Commission took the following actions in the areas of water quality and pollution:[1]

- Provided drafting assistance and recommendations for the Water Quality Act of 1965 (PL 89-234) and for the Water Resources Planning Act (PL 89-80), and supported congressional enactment of the Acts.
- Urged the U. S. Public Health Service to develop a Model Harbor Sanitation

1 Great Lakes Commission, <u>Report to the States</u>, 1965-66, Ann Arbor, Michigan, pp. 19-20

Code of set of standards for guideline procedures in port and harbor sanitation. Thé initial draft of the document was completed and circulated in 1966. Publication date is not fixed.

- Continued its efforts to have established uniform and workable regulations governing the disposal of wastes for watercraft. Efforts continued to have made availabèe the report for the Secretary of Interior on the subject of disposal of wastes from watercraft.

- Supported the construction of the regional water pollution control laboratory for the Great Lakes Region. Construction of this laboratory was authorized in January 1963 and bids for construction were opened in January 1966. No further action has been taken.

- Participated in pollution control enforcement conferences for Lake Michigan and the Calumet area; for the Detroit River and western Lake Erie; and for Lake Erie. The Commission presented statements in support of the enforcement actions and recommended specific activities and actions in the research effort for the effective abatement and control of pollutants, including nutrients and thermal pollutants.

These activities demonstrate the role of a regional agency concerned with assisting the affected states in voluntarily working on management problems having region-wide implications. Although a consistent management approach can be achieved on a problem-by-problem basis, it should not necessarily be assumed that all of the region-wide implications associated with a particular problem can be effectively considered in this approach. On the other hand, even with the on-going planning programs of the Great Lakes Basin Commission and the Upper Great Lakes Regional Commission, this working responsibility to handle problems is a necessary ingredient to the region - wide management of resources. It is also a relationship or function that should be maintained and strengthened as part of permanent arrangement for regional resource management in the Great Lakes Basin.

Another important agency having important functions in the regulation and use of coastal zone resources is the International Joint Commission.(IJC) The IJC was created by the United States and Canadian Boundary Waters Treaty of 1909.

Its main purpose is to act upon all proposals (or applications, as they are called) for the use, obstruction, or diversion of waters flowing across the boundary common to the United States and Canada which would affect the natural level or flow of these waters. The IJC has an additional responsibility to investigate and make recommendations on matters referred to by the respective governments (called "references"). This latter responsibility is becoming a major role of the IJC and is expanding its scope of concern to other resource issues common to the two countries -- such as water and air pollution, and preservation and enhancement of secenic beauty (American Falls).

Three representatives on the IJC are appointed by the President and three by the Canadian Government. Their rulings on applications are final. However, the IJC recommendations on referenced investigations are advisory. The absolute or final authority of the IJC over boundary waters is unquestionably the most important aspect of its activities. Here is a unique case where the responsibility for review and action on regional problems were vested in a single authority whose action was not subject to overruling by a dissatisfied interest.

It is also significant that other regional problems with international implications are increasingly being brought to the attention of the IJC for investigation through references submitted by various agencies of the two countries. Since the recommendations with respect to conclusions derived from the IJC's investigations are advisory, this raises the question as to what would be the advantages (or disadvantages) of extending the authority of control over boundary water to other resource matters such as fisheries or air pollution. Additionally, the study or investigate capability of the IJC is managed on the basis of two national sections utilizing the cooperative study resources of agencies participating in the investigations much in the same way as the Regional and Basin Commissions are operating. As mentioned earlier in the Great Lakes Basin Commission section, regional powers usually evolve on a need basis in which case it might be that the ultimate role of the IJC, or similarly constituted agency, may be to settle disputes on all development and management problems affecting the entire region, which cannot be reconciled nationally or regionally. An alternative would be to re-channel the investigative role of the IJC into one of the newly established regional or basin agencies which are already cooperating with most of the same agencies contributing to or executing the investigations of the IJC. The underlying principle posited here is that the investigative and decision-making functions should be maintained as separate organizations, much as the "bar" is separated from the "bench" in legal matters.

It is to be noted that such an evolution of powers and duties is not one which is encouraged in the legislative mandates which include the call for "cooperation' in establishing the regional agencies in the Great Lakes area. For example, Section 3 of the Water Resources Planning Act specifically identified the IJC as one of the agencies whose powers are not to be considered pre-empted or superseded in the Great Lakes Basin Commission's activities. It is true that statements of this kind are needed to clarify roles between agencies, particularly in overlapping areas in the early stages of program enactment. But at the same time, they also discourage what could be a logical evolutionary transfer of investigative effort as well as the sort of bureaucratic flexibility which would better harmonize the efforts of the various organizations with a measure of overlapping responsibility so as to reduce wasteful duplication. (However, this is not to say that all duplication of effort is necessarily wasteful.)

More limited in scope is the Great Lakes Fishery Commission which was originally established in 1955 by convention between the United States and Canada to formulate R & D programs and to recommend management measures to preserve and enhance the fishery resources of the Great Lakes common to the two countries. At the time, the lamprey eel intrusion has become a major problem; and emphasis was immediately placed on the Commission's activities for developing and implementing measures to control the lamprey problem. Funds for the lamprey control program have been supplied largely by the U. S. and Canadian Governments on a 69 to 31 per cent matching basis as determined by the estimated value of the U. S. and Canadian trout fisheries in the lakes at the time of the convention. These funds are used by the Commission to work with other agencies, chiefly state departments of fish and game and the U. S. Bureau of Commercial Fisheries, in executing lamprey control measures. The Commission is advisory in nature and on a staff basis it informally cooperates with the other regional Commissions. However, few of these coordinating relationships are formally recognized as such (e. g., the staff contributions to the Great Lakes Basin Commission's fishery studies). Much of the Great Lakes Fishery Commission's investigations are conducted in cooperation with participating state and federal agencies in a manner similar to the Upper Great Lakes Regional Commission, the Great Lakes Basin Commission, and the IJC.

The most important aspect of the Commission's activities is its responsibility in managing the dynamic fishery resource which is common to the United States and Canada. In this respect, the Commission's activities are quite similar to the investigations of the IJC. This again raises a number of important questions:

(1) What kind of decision-making and investigative role should be set up for region or basin-wide responsibility?

(2) To what extent should functional resource research and resource management

be conducted on a single-purpose basis for the region, not only for fisheries and other water-related areas -- but for all resources [1]?

(3) To what extent should natural resource matters, in addition to boundary water control, have the benefit of regional decision-making?

The roles of the Great Lakes Fisheries Commission and the IJC present three precedents for approaching regional problems:

- o The setting up of a special review board to act on special resource problems, with the burden of responsibility for investigation and fact presentation on the respective parties seeking approval or disapproval of a particular activity or project;
- o An increasing need for an investigative responsibility to handle a variety of region-wide water-related problems having international aspects; and
- o A study and management group with responsibility for one functional resource area.

With respect to the first precedent, the question arises: Why limit this kind of decision-making only to boundary-water matters? Are there not other regional problems that could benefit from having such a "court-of-last-resort" to settle disputes and reconcile interests through a neutral review board? Also, with respect to the latter two precedents, should other regional resource functional areas be attended to by a special regional Commission to handle their problems and potentials? Or should all such investigations be handled under one

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1 Even on a single-purpose basis, most functional programs are attempting to adopt comprehensive outlooks. Some have gone so far as to establish "comprehensive" planning programs as part of their functional operations. With several comprehensive planning programs going on in the region, the need arises for their coordination to develop consistency of objectives and goals and to avoid unnecessary duplication of effort in planning research or information-gathering tasks.

organization, which might or might not also be a decision-making organization? Are there other regional organizations now established in the Great Lakes area which could better handle investigations of functional resource problems of a regional significance? These matters, it would appear, are deserving of attention in arriving at a more satisfactory organizational framework.

As an obvious example of the possibilities of reorganizing the institutional arrangements in the Great Lakes Region to better accommodate review of region-wide matters, it would seem advantageous for either the Great Lakes Basin Commission or the Great Lakes Compact Commission to be designated to plan for the primary research and conduct the investigative work of the IJC and the Great Lakes Fisheries Commission. Also, consideration should be given to the expansion of IJC's décision-making role to include a broader-based arbitration and dispute-based arbitration and dispute-settling platform for region-wide problems that cannot otherwise be reconciled through state or national and international negotiation. It would seem in the case of fisheries, for example, that the broader implications of fishery management measures within the eco-system of the Great Lakes or the determining of economic policy dealing with consequences between sport and commercial resource development strategy transcends the traditional investigative capacity of the fishery expert in the context of region-wide comprehensive planning. It is true (as in the case of the lamprey ~~eel~~ eel) that a problem of extreme regional importance may arise from time to time which may require special action to establish a group to study and possibly execute remedial measures on a large scale for a limited period of time. The continuing tenure for such a measure and its institutional relationships is another question that might well be subject to the continuing review and possible re-disposition in line with other resource use and management policies and programs in the Basin.

Table I contains a partial list of institutional measures used by government agencies and other organizations to control or influence the use of resources in the Great Lakes Region, including natural, capital, and human resources. Although the attention of this study focuses on the effect of these measures on the use of resources in the Great Lakes coastal region and , more specifically, the coastal zones of Lake Superior and Lake Erie, this list was developed as a result of a region-wide review of institutions regulating the use of these resources or in other ways influencing their development. the foremost example of direct controls is the use of zoning regulations as a tool for enforcing the implementation of an adopted city or county comprehensive plan, or other development policy or strategy. Zoning regulations or ordinances can control the kind of use, such as agricultural or industrial, as well as other factors relating to the conduct of use, such as agricultural or industrial, as well as other factors relating to the conduct of use, such as the Duluth zoning ordinance requiring industry in certain strategic shoreline locations to be "water-orientated". On the other hand, the actions of other public agencies -- such as freeway builders or port developers -- which for the most part are exempt from zoning regulations may also influence the use of land and water areas, population distribution, and economic activity beyond their immediate program or project-orientated objectives. Public Works projects have an indirect impact on influencing the use of resources in many instances which is far more reaching than direct control measures such as zoning.

This list of Table I organizes a number of key institutional control measures

Table I

Institutional Measures for Controlling, Regulating, and Otherwise Influencing the Use of Resources in the Great Lakes Region

1.) Government Administrative Procedures

Budget Formulation and Review
Program Requirements (Administrative)
Executive Authority (Granted by Legislative Body)

2.) Government Operations and Programs

Public Works Projects

Public Works Coordination
Capital Improvement Programming

Disposition and Management of Public Lands

Sales, Leases, and Royalty Payments
Management Policies

Cooperation (Flexibility in Government Projects)
Conduct of R&D, Planning, and Forecasting
Collection and Dissemination of Information
Provision of Technical Assistance
Timing of Activities
Eligibility Requirements or Cooperative Obligations for Receipt of Services or Products
Education and Training
Provision of Facilities and Services (Such as recreation, health, safety, rescue, transportation, welfare, property protection, law enforcement, and other social measures)

3.) Special Government Economic and Financial Measures

Fiscal Policies

Taxation

Incentive Measures (deferments, exemptions, tax rate reduction)
Discouragement Measures (increase of tax rates)

Financial Assistance

Grants
Loans (guaranteed and low interest)
Cost Sharing (par and non-par)

Eligibility Requirements
Performance Requirements

Import Tariffs and Quotas

Monetary Policies

Credit Control Regulations
Borrowing Powers
Federal Reserve Board Actions

4.) Other Governmental Regulatory Measures and Powers

Approval, Authorization, and Appropriation of Budget Expenditures
Zoning - (Use of Police Power to Enforce Use Regulations)
Subdivision Regulations
Deed Restrictions
Architectural Requirements and Standards
Public Health Codes
Building Codes
Setting Production Allowances or Quotas
Antitrust Laws and Administration
Laws Pertaining to Water Rights
Laws of Ownership and Property Jurisdiction
Access Control
Power of Eminent Domain
International Agreements and Commitments
Public Utility Regulations
Patent Laws

which are being utilized by the various functional agencies, organizations, and different layers of government. For instance, some measures particularly lend themselves to, or historically have been the responsibility of, city and county governemnt, such as the zoning authority previously mentioned. Other measures are more applicable on a regional level, such as the decision for a new major air transportation facility or water management practices involving lake level variation.

Inherent in the five regional agencies discussed above is the capability for planning, coordinating, making decisions, and implementing programs on a regional basis in the Great Lakes Basin. However, this capability,is disjointed and needs to be molded into a more consistent, efficient, and rational institutional arrangement which will enable these functions to operate efficiently and the fruits of their findings and expert contributions to be affected to the maximum extent possible.

These agencies commonly rely on the cooperation of federal and state operating agencies in the conduct of special investigations and component study elements of the comprehensive planning programs for which they are responsible. Therefore, the task of conducting research and planning studies still remains with the experts in the functional agencies. For this reason, a considerable coordination is accomplished almost "automatically". For example, many of the experts in a particular functional area such as water pollution (the FWPA), or water transportation (the U. S. Army Corps of Engineers) participate in the study groups of several regional bodies, and thereby contribute firsthand working level coordination. Additionally, these working-level people have initiated special groups on their own to inform and to keep one another up to date on their respective research and study activities, such as the Great Lakes Study Group and the Federal Interagency Committee on Great Lakes Research.

Indeed, the coordination of efforts to solve the problems and to utilize the opportunities for growth and welfare of the Great Lakes Basin is a tremendous task -- in terms of both the complexity of the interrelationships of the physical and social resources involved and the organizational and institutional requirements to effectively accomplish this task. It was found that much work and effort is being put forth at the working levels of the many agencies towards "coordination"; but somewhat understandably, a much lesser effort of this kind is being exerted at the top levels of the regional organizations who are among the chief coordinators of regional affairs. At the level of federal agency participation, the Bureau of Commercial Fisheries, for example, is playing a significant role in the fishery elements of each of these programs, and in this process is undoubtedly contributing knowledge and other assistance derived from its working relationship with the Great Lakes Fisheries Commission and the many other state fisheries agencies in the Basin. From the overall decision-making viewpoint, and especially from the national policy viewpoint of marine science affairs, it would appear that one regional organization should be designated to have the primary responsibility to recommend Basin goals and priorities as these relate to multiple uses of the coastal zone so that a standard may be set to guide coordination between public and private organizations.

The Great Lakes Basin Commission is an example of the kind of organization thru which planning and coordination of decision making may occur on a regional basis, including the provision of an avenue for cooperation with the Marine Sciences Council in the administration of national interest in optimum use of the coastal zone. As mentioned above, steps to define goals for the Great Lakes

Basin - and from which priorities for action programs in Lake Erie and Lake Superior may be derived - are being formulated in the Great Lakes Basin Commission's Comprehensive Framework study " to provide a broad guide to the best use, or combination of uses, of water and related land resources of a region to meet foreseeable short and long term needs."[1] The broad economic and social goals have been further defined in three objectives for framework studies: (1) national income, (2) regional development, and (3) environmental quality.

The national income objective of water resources planning for the Great Lakes Basin, which includes the coastal zone, is to increase national income through investment in water resources development. The potential increase in national income is assessed by estimating the excess of projected benefits over (total) costs of water resource development and management programs proposed to meet demand for water and water-related uses. The Marine Science Council could contribute to this objective by supporting the steps necessary to develop information -- including R&D on the relevant measures involving marine science and technology to facilitate the assessment of costs and benefits by the Great Lakes Basin Commission in their planning effort.

The regional development objective of water resources planning is to increase employment and create an environment that encourages or permits economic development in an area through investment in water resource development, particularly in developing depressed areas. An example of criteria for choosing programs and development actions for economic development is seen in the rationale used by the Upper Great Lakes Regional Commission for singling out proposals from an inventory of action projects previously developed in the region. The criteria states

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1 Great Lakes Basin Comprehensive Framework Study, Plan of Study Document, Great Lakes Basin Commission, Ann Arbor, Michegan, September 1968.

that a project should.[1]

(1) Be regional in character, multi-state in coverage or responding to a a problem common to all three states (Minnesota, Wisconsin, and Michigan).

(2) Affect favorably employment and income.

(3) Stimulate follow-up private investment.

(4) Have immediate visibility and impact on the region.

(5) Provide essential information on which to base long-range investment plans of a public and private nature.

(6) Improve resource quality and availability in order to enable the eventual expansion of resource-using industries.

(7) Public works projects be necessary to the regions infrastructure and which require a number of years before completion.

(8) Include provision for a future dimension of program formulation.

The Marine Sciences Council could contribute to this objective through assessing the manner in which employment and income can be generated through the application of measures in marine science and technology.[2]

The environmental quality objective involves the preservation and enhancement of the cultural and aesthetic values in the process of resource use and development. These objectives in their execution in the coastal zone may involve the

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1 <u>Working Papers and Regional Project Proposals for Early Action Program</u>, Upper Great Lakes Regional Commission, Washington, D. C . March 1968, pp. 2 - 5

2 Preliminary pilot studies in this area have been made by the National Planning Association under contract to the National Council on Marine Resources and Engineering Developemtn and the National Science Foundation: <u>Cf</u>., Spangler, Miller B., A Preliminary Review of Alternative Federal Measures of Encouraging Private Investment Enterprise in Marine Resource Development, Commerce Clearinghouse Publication PB-178-203, Springfield, Virginia, May 1968, 140 pp.; and Bigler, Alexander B., " A Preliminary Review of Current Problems of Manpower and Capital Resource Utilization in Maritime Regions and Possibilities for their Solution," National Planning Association, Washington, D. C., January 1968, 49pp. (unpublished)

postponement of resource development for future availability when their "best" use is needed. In this case, a lower level of investment in resource development is made to preserve environmental quality. On the other hand, a higher level of investment may be required to preserve the quality of water used or required to meet present commitments. If the attainment of environmental quality objectives is given priority over regional economic development objectives, (as suggested in the Framework Study document), the imposition of quality standards may tend to restrain development of resources. Accordingly, this could discourage new industrial investment on the one hand, or on the other, require higher levels of capital investments for existing installations to achieve abatement of undesirable by-products of resource use. To illustrate this point, Lake Superior is still relatively unpolluted because there has been a "low level of investment" in the exploitation of resources in the basin. To maintain this level of environmental quality this low level of investment must be maintained, or in the event of increased resource use, a higher level of investment will be required to preserve the quality of water and the environment from the undesirable by-products of economic development. In the case of Lake Erie, the higher levels of investment for environmental quality over and above investments in economic developments are only now being required.

The Marine Sciences Council could contribute to the objective of environmental quality by supporting pertinent R&D in marine science and technology and encouraging related fields of R&D such as sewerage treatment to achieve greater cost-effectiveness in pollution abatement measures. For instance, R&D would be beneficial to more exactly determine the conditions under which modifications in shoreline configurations (discussed in Part III) could contribute substantially to the diluting of polluted waters along recreation beaches or other waterfront areas. This is particularly important in view of the trend toward intensive use of the resources of the coastal zone and the resulting high cost of pollution control measures at the present level of technology.

The Great Lakes Basin Commission has stated that the overall regional objective in water and related land resource development is the maximum possible utilization of these resources in the Great Lakes Region for the benefit of its people for all purposes and uses. These include:

- Adequate municipal and industrial water supplies;
- Maximum possible low-cost water navigation, both lake and inland;
- Clean water for recreation, fish and other uses;
- Adequate water supplies for irrigation for an expanding economy;
- The maintenance and enhancement of fishery resources;
- Adequate hunting opportunities;
- The preservation of the regions sail resources;
- The control or prevention of floods; and
- Adequate low-cost electric power supplies, and for domestic and industrial use.

The States represented on the Great Lakes Basin Commission have expressed the subregional interests or second level objectives in the maximum efficient use of water reflected in programs for development or preservation of coastal zone resources of the Great Lakes Region.[1] In its role to promote the optimum use of the coastal zone of Lake Erie and Lake Superior (as well as the other Great Lakes) the Marine Sciences Council through cooperating with the Great Lakes

[1] Great Lakes Comprehensive Framework Study, op. cit..

Basin Commission can better assess relative priorities for the measures of marine science and technology which can be applied, and which will serve to achieve both national and regional interests. In this case, the regional interests should be derived from the objectives expressed by the respective states, as listed below.[1]

The States of Minnesota, Wisconsin and Michigan have identified the following overall objectives for the Lake Superior Basin:

Minnesota

(1) Improve water related mineral use and management.

(2) Improve navigation of the Great Lakes.

(3) Develop and enhance recreation, natural areas, fish and wildlife.

(4) Increase power development.

Wisconsin

(1) Enhance economic opportunity through water and related land resource development.

(2) Maintain high quality environment as a base for a recreation industry.

Michigan

(1) Develop maintenace of a high quality environment, particularly the inland and Great Lakes waters; expansion of economic opportunities through resource development and outdoor recreation.

With respect ot Lake Erie, the adjacent States expressed the following objectives:

Michigan

(1) Achieve and maintain environmental quality consistent with rapid urbanization, industrial expansion and expansion of recreational opportunities.

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[1] Ibid..

Ohio

(1) Increase water supply.

(2) Improve water quality.

(3) Achieve low flow augmentation.

(4) Establish flood control and flood plain management.

(5) Develop recreation.

Pennsylvania

(1) Develop navigation.

(2) Develop recreation which is dependent on beach stabilization at Presque Isle State Park.

(3) Improve water quality as related to commercial and sport fishing.

New York

(1) Improve water supply and water quality to meet the water resources demands of the Buffalo SMSA.

(2) Develop flood control.

(3) Develop recreation.

(4) Increase water supply.

(5) Improve water quality.

(6) Develop New York State Barge Canal System as a total water resource.

While the above objectives express the regional objectives as viewed by the respective States, the Marine Sciences Council will still have to rely upon a national planning agency -- such as the Great Lakes Basin Commission -- to establish the relative weights which should be given to the priorities on a regional scale. For instance, while all of the States cited the "recreation" objective, recreation is by no means the program activity receiving the largest financial support. It is also interesting to note that Michigan --

bordering both Lakes (Erie and Superior) -- stressed environmental quality which includes more aspects than the water quality objective espoused by the other three states bordering Lake Erie. Regarding Lake Superior, Minnesota and Wisconsin did not stress either water or other environmental quality objectives. The regional objectives most commonly expressed by the Lake Superior States are recreation and economic opportunity. These examples demonstrate the planning work that remains to be done to develop a sense of regional priorities common to the development objectives of respective states and which the regional planning program of the Great Lakes Basin Commission is striving to achieve.

There are several alternative ways by which the Marine Science Council could cooperate in representing the national interest in the optimum use of the coastal zone of the Great Lakes Region, particularly with respect to coordinating national efforts/ in marine science and technology with the formulation and carrying out of development goals for the Great Lakes Region. These include the following:

(1) Appointment of a representative of the Marine Sciences Council to Great Lakes Basin Commission, either as a full voting member or as an <u>ex officio</u> member.

(2) Development and inclusion of a Framework study element concerned with the coastal zone (as described above) to be conducted under the auspices of an agency or agencies designated by the Marine Sciences Council in cooperation with the Great Lakes Basin Commission.

(3) Referral of the Framework Study and Great Lakes Basin Commission program plans to the Marine Sciences Council for review and comment.

(4) Establishment of a separate continuing coastal zone planning and management study group under the Marine Sciences Council or designated lead agency whose regular reporting to the Council would be available on an advisory basis to all other federal and regional agencies, state and local jurisdictions, and private entities.

PART II

PRESENT AND FUTURE USES OF THE COASTAL ZONE

General Description and Inventory of the Coastal Zone

Physical features.--Lake Erie and Lake Superior are strategic components of the Great Lakes System which consists of five huge lakes connected by relatively narrow straits of which the St. Clair-Detroit River System of 77 miles is the longest (see Figures 1 and 2). This system constitutes the largest fresh water resource in the world. The Great Lakes drainage basin is over 240,000 square miles of which nearly 40%, or 95,120 square miles, is lake surface. Except for the Upper Michigan Peninsula, much of the remaining land in the watershed is within 50 miles of the Great Lakes Coast. For this reason, as mentioned earlier, river basin planning importantly interrelates to the coastal zone uses which are the basic concern of this study.

Because of their large size, the lakes are essentially inland seas with a distinct pattern of geography, climate, meterology and hydrological relationships. While the flow in the connecting straits is swift, the lakes are characterized by the limited variation in flow from lake to lake and to the St. Lawrence -- varying on the order of only plus or minus 25% from the average. This causes a great equalizing effect on the storage of water in the lakes.

The complex hydrological, bathymetric and physical features of the Lake System are characterized in Figures 2 and 3 and in Table 1. Comparisons between Lake Superior and Lake Erie show that Lake Superior is 45% longer than Lake Erie (350 vs. 241 miles) and has a mean depth which is 8.4 times that of Lake Erie (487 vs. 58 feet), a water surface area that is 3.2 times that of Lake Erie (32,000 vs. 10,000 sq. mi.). Although Lake Erie has a mean discharge of 196,000 cu. ft. of water per second, which is 170% greater than the mean discharge rate of Lake Superior, there has been a substantial buildup of pollutants of chemicals and dissolved minerals

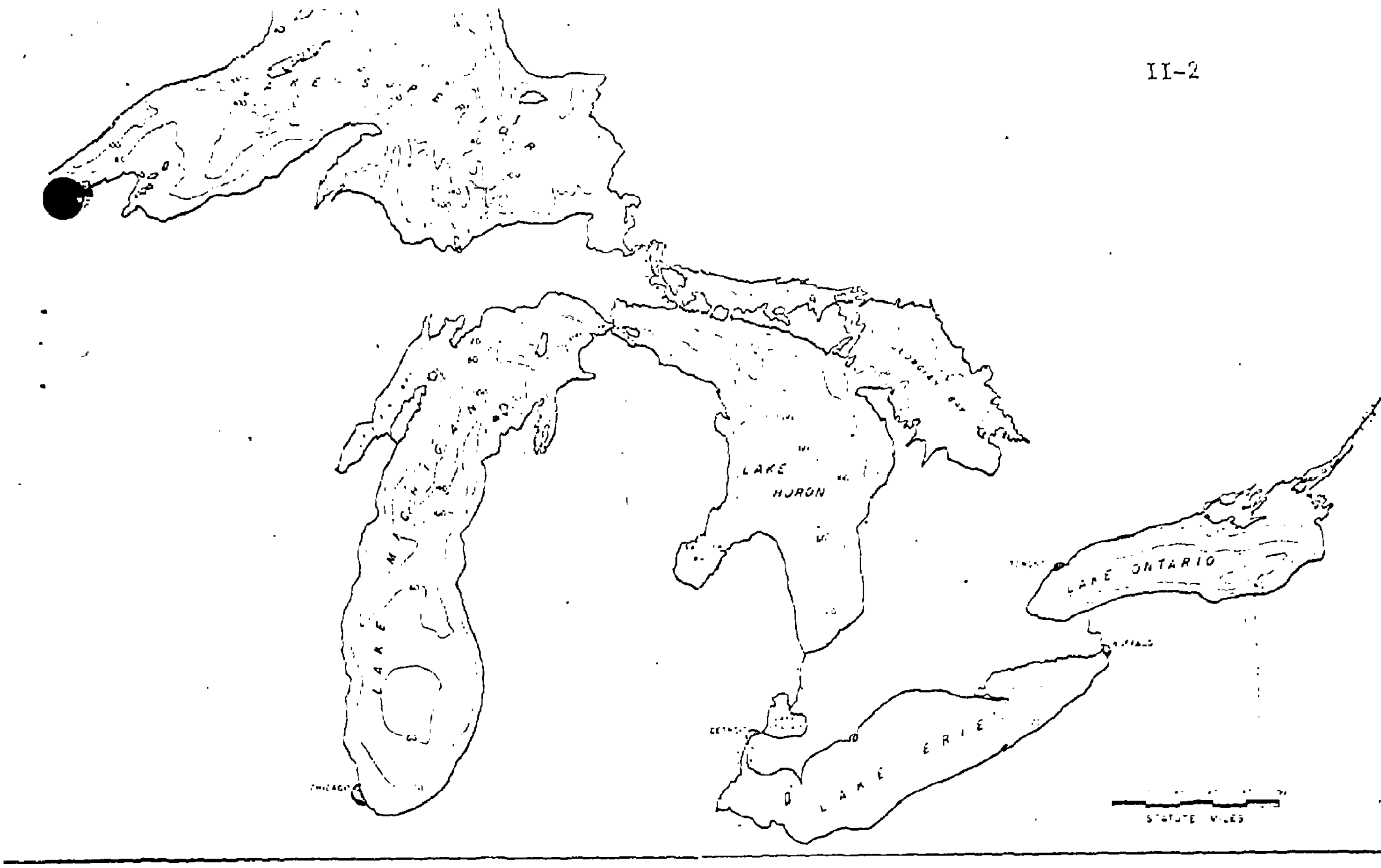


Figure 1.--Great Lakes, showing major depth contours in fathoms.

Table 1.--Dimensions of the Great Lakes[a]

Lake	Length (mi)	Breadth (mi)	Area: Water surface (mi^2)	Area: Drainage basin (mi^2)	Average surface elevation above mean sea level since 1860 (ft)	Mean discharge (cfs)	Maximum depth (ft)	Mean depth (ft)
Superior	350	160	31,820	80,000	602.20	73,300	1,333	487
Michigan	307	118	22,400	67,860	580.54	55,000	923	276
Huron	206	183	23,010	72,620	580.54	177,900	750	195
St. Clair	26	24	490	7,430	574.88	178,000	21	10
Erie	241	57	9,930	32,490	572.34	195,800	210	58
Ontario	193	53	7,520	34,800	246.03	233,900	802	283

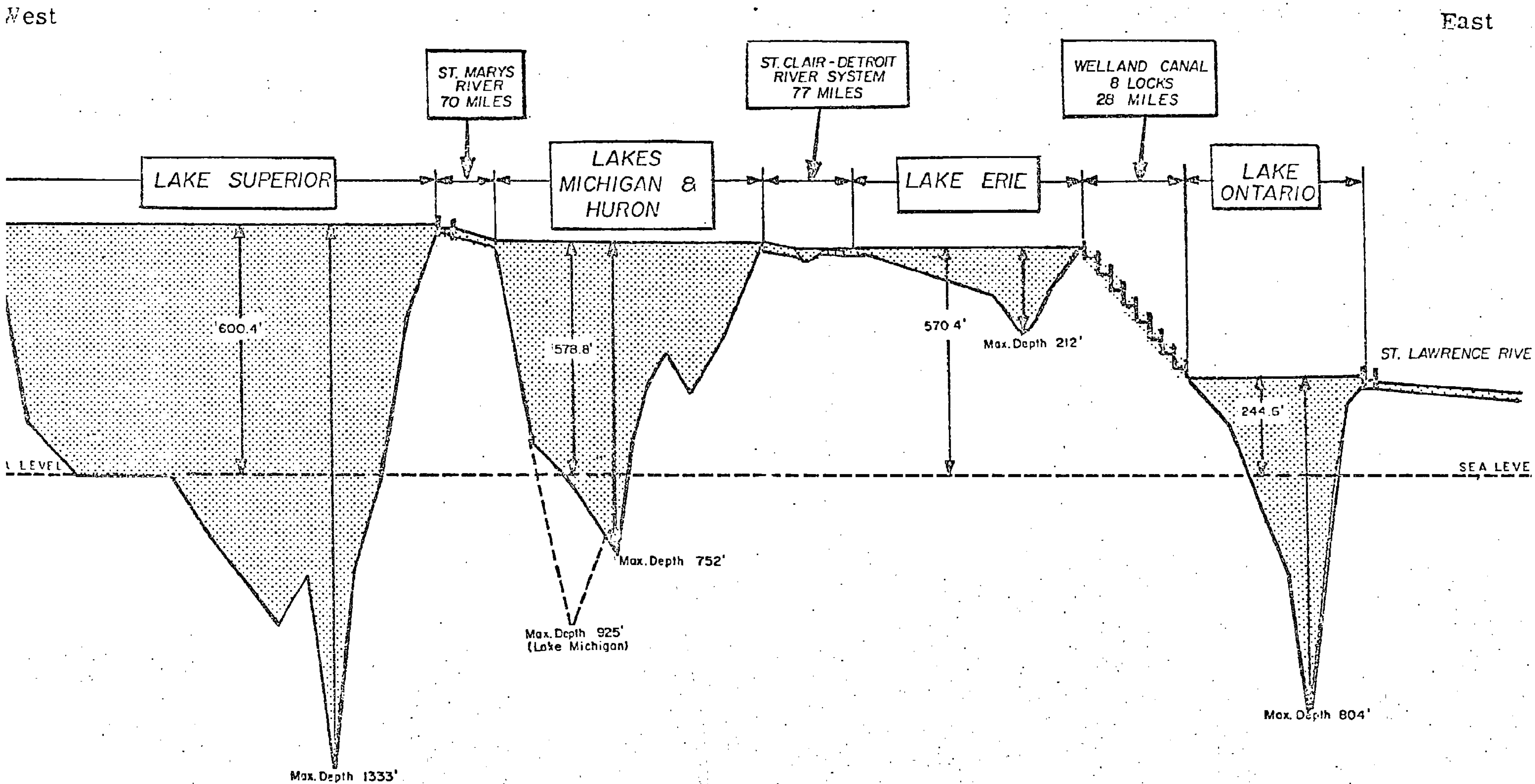
[a] Data from U.S. Army, Corps of Engineers (1960) or personal communication.

Average chemical characteristics of Great Lakes waters. U.S. Bureau of Commercial Fisheries data, unless designated otherwise. Data based on samples from various depths.

Lake	Calcium (ppm)	Magnesium (ppm)	Potassium (ppm)	Sodium (ppm)	Total alkalinity (ppm $CaCO_3$)	Chloride (ppm)	Sulfate (ppm)	Silica (ppm)	Total phosphorus (ppb)	pH	Specific conductance (micromhos at 18° C)
Superior	12.4	2.8	0.6	1.1	46	1.9	3.2	2.1	5	7.4	78.7
Huron	22.6	6.3[a]	1.0	2.3	82	7.0	9.7	2.3	10	8.1	168.3
Michigan	31.5	10.4	0.9	3.4	113	6.2	15.5	3.1	13	8.0	225.8
Erie	36.7	8.9	1.4	8.7	95	21.0	21.1	1.5	61	8.3	241.8
Ontario	39.3	9.1[b]	1.2	10.8	93[c]	23.5	32.4	0.3	—	8.5[c]	272.3

[a] Ayers *et al.*, 1956.
[b] Leverin, 1947 (average from Toronto intake).
[c] New York State Dept. Health, 1958.

Data from: Beeton, A.M. and Chandler, D.3C. 1963. in "Limnology in North America," University of Wisconsin Press, p. 535.



Lake	SUPERIOR	MICHIGAN	HURON	ERIE	ONTARIO
Extreme Length, Miles	350	307	206	241	193
Extreme Width, Miles	160	118	183	57	53
Area, Square Miles	31,800	22,400	23,000	9,900	7,600
Average Depth, Feet	487	276	195	58	283
Volume, Cubic Miles	2,933	1,169	848	109	407

Figure 2. Profile of the Great Lakes portion of the St. Lawrence Seaway. Note: the profile passes the deepest point in each basin. A ship would follow a somewhat shorter track.

Source: Mortimer op. cit..

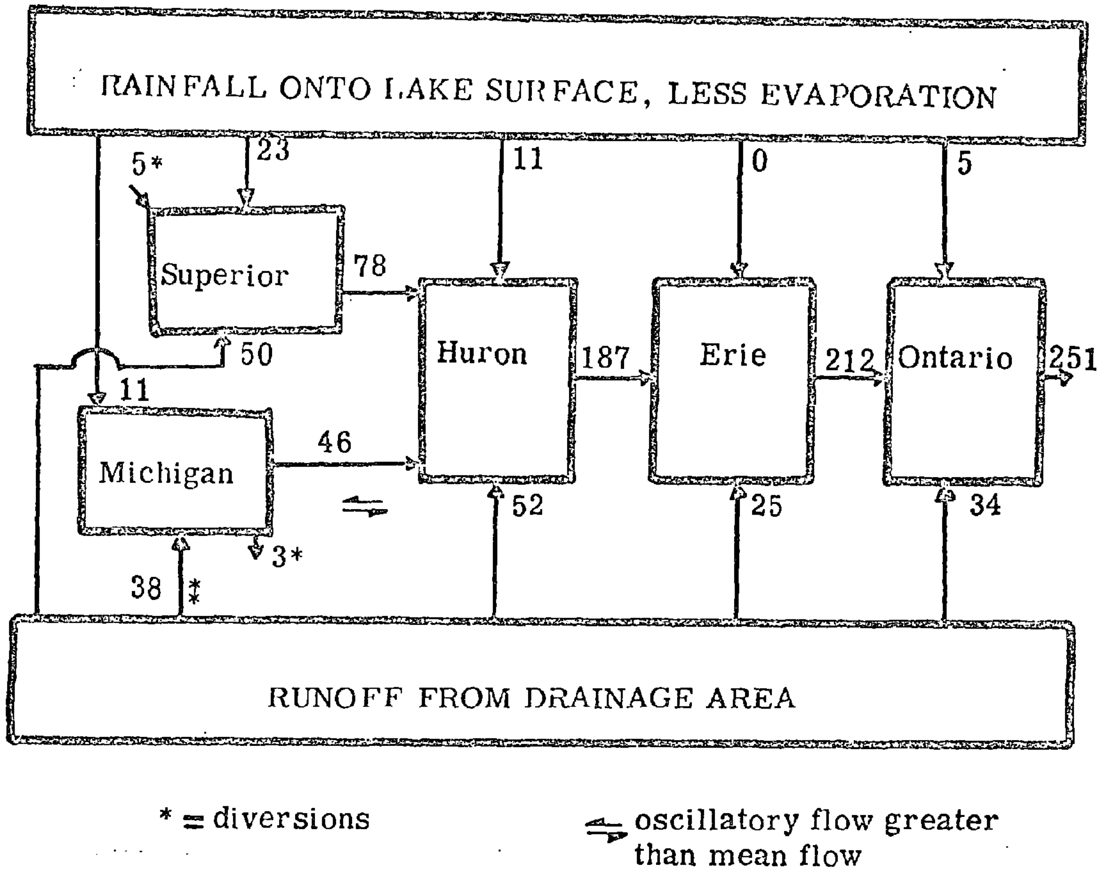


Figure 3.--Flow diagram (in units of thousand cubic feet per second) for the Great Lakes, assuming steady lake levels and based on U.S. Lake Survey 1950-60 averages.

**Less than 4% of this passes into the lake across the most highly populated shoreline from Milwaukee, Wisconsin, south and east through Chicago, Illinois, to Michigan City, Indiana.

Source: Mortimer, op. cit..

in Lake Erie. Table 1 shows that Lake Erie has about 3 times as much calcium and magnesium, 2.3 times as much potassium, 8 times as much sodium, 11 times as much chlorine, 12 times as much phosphorous, 6.6 times as much sulfate, and twice the alkalinity than Lake Superior. Many of the biological and ecological effects of these dissolved substances on marine life are yet to be evaluated, but the greater nutrients or fertilizer materials found in Lake Erie have greatly accelerated algal growth and the process of eutrophication as discussed elsewhere in this report.

As seen in Figure 3, Lake Erie is the only one of the Great Lakes where rainfall onto the lake surface does not exceed the evaporation loss of water from the lake surface. Moreover, Lake Erie receives only 12% of its drainage inflow water from its own onshore drainage area versus 88% received from Lake Huron. Clearly, the increased pollution of Lake Huron -- and Lakes Michigan and Superior which feed into Lake Huron -- brings adverse effects on the quality of water of Lake Erie. However, it is to be noted that the average volume of water entering Lake Erie each year from Lake Huron is only about 4% of the total volume of water contained in Lake Erie (109 cu. mi. or 147 billion cu. ft.). This indicates a substantial lag in the effect of pollution buildups in Lakes Michigan, Huron, and Superior on the level of pollution in Lake Erie. By the same token, even if all pollution entering Lake Erie were halted, at the average rate of drainage from Lake Erie of 212 cu. ft. per sec., it would take about 22 years for nature to remove a volume of water equivalent to that now contained in the lake.

Major uses of the coastal zone.--The Great Lakes Region represents one of the most important geographic divisions of the United States in terms of concentration of population, manufacturing, agricultural production, and income. Three of the most important urban concentrations in the United States are located in the Region; and together these are in the process of forming an important megalopolis, second only to that of the northeastern Atlantic Seaboard. The strategic importance of the Great Lakes and the St. Lawrence Seaway as an inland waterway transportation system is revealed by the fact that approximately 40% of the raw materials consumed in the United States pass through Great Lakes ports. Moreover, most of the important socio-economic activities in Canada are concentrated around the Great Lakes.

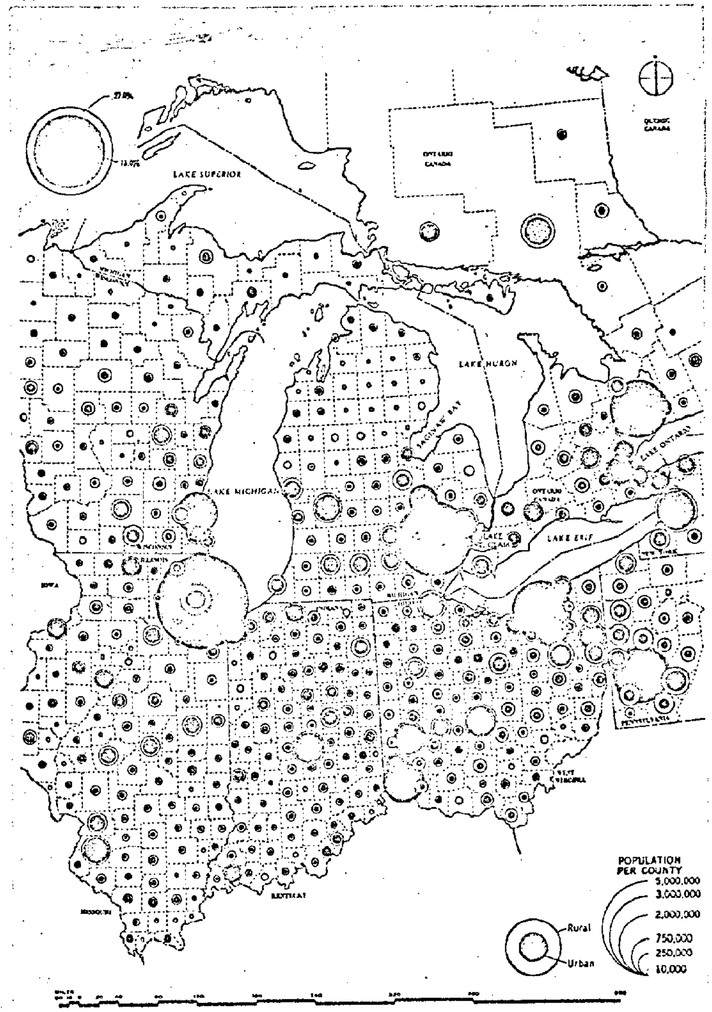
Undoubtedly, the coastal zone resources will play a key role in supporting the growth of the Great Lakes megalopolis. The growth in population and economic activity will be dependent upon the provision of sufficient quality and quantity of water from the Great Lakes. Also, the allocation of the scarce resource of lake shoreline frontage will become an increasingly important factor in the flux of human and natural resources through the coastal zone.

The Great Lakes megalopolis appears to be forming around the three major urban clusters in the region -- the Chicago, Detroit, and Cleveland-Pittsburgh areas -- as shown in Figure 4. These three urban clusters are being bridged by a continuous chain of urban development as shown in Figure 5.

Two main urban axes are forming from the major concentrations. One main urban axis, the Chicago-Detroit-Toronto complex, is evident by its extension north of Lake Erie and Ontario through Canada. This extension divides at Hamilton on the western end of Lake Ontario with one arm proceeding towards Montreal and Quebec and another arm extending towards Buffalo and the Mohawk Valley to New York City. The other main axis extends along a line connecting the Chicago-Detroit and Cleveland-Pittsburgh clusters, with further evidence of extension through the Potomac River Valley to Washington, D. C. In addition to these two main urban areas, a third minor axis is emerging along the southern shore of Lake Erie connecting the Toledo-Cleveland-Buffalo clusters.

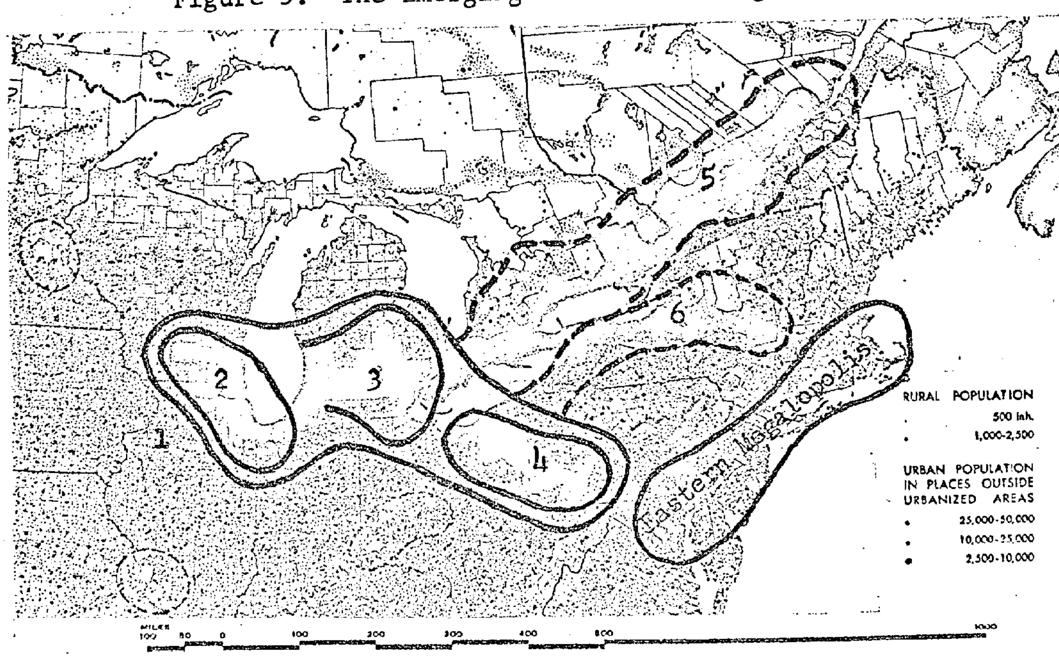
The 1960 population figures reported an aggregate population of 37 million for the eastern seaboard megalopolis and 22 million for the Great Lakes megalopolis.

Figure 4.--Population Distribution 1960



Source: Emergence and Growth of an Urban Region, The Detroit Edison Company, Detroit, Michigan, 1967, pp. 4 and 9 respectively.

Figure 5.--The Emerging Great Lakes Megalopolis



1- Main Great Lakes Megalopolis
2- Chicago Cluster
3- Detroit Cluster
4- Cleveland-Pittsburg Cluster
5- Canadian-St.Lawrence Seaway Extension
6- Mohawk Valley Extension

Assessments of the growth potential of the Great Lakes Region have led to the prediction that the Great Lakes megalopolis will surpass the eastern megalopolis in population by the year 2000.

The prospective of an emerging Great Lakes megalopolis suggests that the size and complexity of the problems of coastal zone use may be compounded by the year 2000. This further implies that measures for marine science and technology must be developed not only to accommodate current problems in achieving optimum beneficial use of the coastal environment, but also to make sufficiently viable such measures that would provide the foundation for solving problems of at least twice the current magnitude within the next thirty years.

Over 80% of the 28 million people in the U.S. part of the Great Lakes Basin live in the metropolitan urban areas of Syracuse, Rochester, Buffalo, Erie, Cleveland, Akron, Toledo, Detroit, Fort Wayne, Flint, Saginaw, Grand Rapids, South Bend, Chicago, Gary, Milwaukee, Green Bay, and Duluth. In Figure 6, it is seen that in 1960 the U.S. part of the Lake Erie Basin held the largest population (about 40%) and Lake Superior the least (4%). Over 11 million people lived in the Lake Erie Basin in 1960 of which almost 8.6 million (or 78%) resided within the counties immediately adjacent to Lake Erie (see Table 2). Indeed, about 8 million of the latter population (or 94%) were concentrated in the 6 major metropolitan areas along the shoreline: Detroit, Cleveland, Lorain-Elyria, Toledo, Erie, and Buffalo. This shoreline concentration of population in the Lake Erie Basin and its metropolitan orientation clearly suggest that urban interests will hold major import for measures in marine science and technology designed to facilitate optimum use of the coastal zone of Lake Erie.

By contrast, only about half of the one million U.S. population in the Lake Superior Basin in 1960 was located along the shoreline. However, about 54% of the latter (see Table 3) was located in the one metropolitan area (Duluth-Superior).

Except

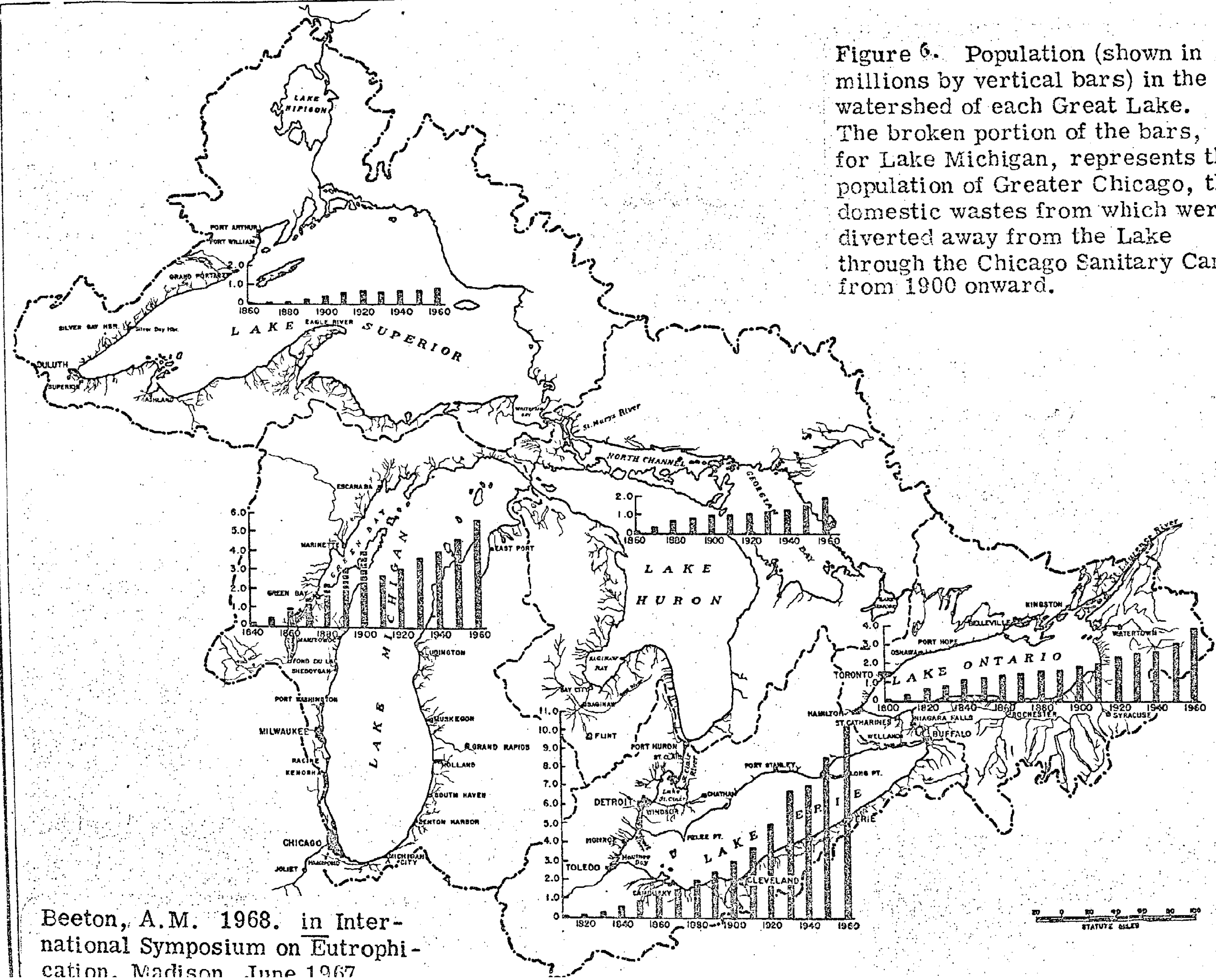


Figure 6. Population (shown in millions by vertical bars) in the watershed of each Great Lake. The broken portion of the bars, for Lake Michigan, represents the population of Greater Chicago, the domestic wastes from which were diverted away from the Lake through the Chicago Sanitary Canal from 1900 onward.

Beeton, A.M. 1968. in International Symposium on Eutrophication. Madison, June 1967

TABLE 2

1960 POPULATION OF U.S. COUNTIES AND METROPOLITAN AREAS
ADJACENT TO LAKE ERIE

State	County[1]	Total	Metropolitan[2] Area	Counties Included	Total
Michigan			Detroit		
	St. Clair	107,201		Macomb	405,804
	Macomb	405,804		Oakland	690,259
	Oakland	690,259		Wayne	2,666,297
	Wayne	2,666,297			3,762,360
	Monroe	101,120			
		3,970,681			
Ohio			Cleveland		
	Lucas	456,931		Medina	65,315
	Wood	72,596		Cuyahoga	1,647,895
	Ottawa	35,323		Geauga	47,573
	Sandusky	56,486		Lake	148,700
	Erie	68,000			1,909,483
	Lorain	217,500	Lorain-Elyria		
	Medina	65,315		Lorain	217,500
	Cuyahoga	1,647,895	Toledo		
	Geauga	47,573	(Ohio portion)	Lucas	456,931
	Lake	148,700		Wood	72,596
	Ashtabula	93,067	(Mich.portion)	Monroe	101,120
		2,909,386			630,647
Pennsylvania			Erie		
	Erie	250,682		Erie	250,682
New York			Buffalo		
	Chautauqua	145,377		Erie	1,064,688
	Erie	1,064,688		Niagara	242,269
	Niagara	242,269			1,306,957
		1,452,334			
	Grand Total:	8,583,083		Grand Total:	8,077,629

1 Table of Great Lakes Counties, IDCOZ, Marine Sciences Council, August 29, 1968, 4 pp..

2 Standard Metropolitan Statistical Areas, Executive Office of the President, Bureau of the Budget, Office of Statistical Standards, (Washington, D.C.: U.S. Government Printing Office), 1967, 56 pp..

TABLE 3

1960 POPULATION OF U.S. COUNTIES AND METROPOLITAN AREAS ADJACENT TO LAKE SUPERIOR

State	County[1]	Total	Metropolitan[2] Area	Counties Included	Total
Minnesota			Duluth-Superior		
	Cook	3,377	(Minn.portion)	St. Louis	231,588
	Lake	13,702			
	St. Louis	231,588			
		248,667			
Wisconsin					
	Douglas	45,008	Duluth-Superior		
	Bayfield	11,910	(Wis.portion)	Douglas	45,008
	Ashland	17,375			
	Iron	7,830			
		82,123			
Michigan					
	Gogebic	24,370			
	Ontonagon	10,584			
	Houghton	35,654			
	Keweenaw	2,417			
	Baraga	7,151			
	Marquette	56,154			
	Alger	9,250			
	Luce	7,827			
	Chippewa	32,655			
		186,062			
Grand Total:		516,852			276,596

1 Table of Great Lakes Counties, IDCOZ, Marine Sciences Council, August 29, 1968, 4 pp..

2 Standard Metropolitan Statistical Areas, Executive Office of the President, Bureau of the Budget, Office of Statistical Standards, (Washington, D.C.: U.S. Government Printing Office), 1967, 56 pp..

for this latter area and a few lesser coastal cities, it is a reasonable inference that measures in the marine sciences to facilitate optimum use of the coastal zone of Lake Superior will be more resource-base orientated than heavily conditioned to urban interests or needs.

According to NPA projections (see Table 4), the urbanized pattern of the coastal zones of Lakes Erie and Superior in 1960 will persist in future years. The Lorain-Elyria metropolitan area is projected to have the most rapid annual rate of growth (2%) in the Lake Erie Basin during 1966-85 while Duluth-Superior is projected to grow at an even more rapid rate of 2.5% per year during this same period. It is noteworthy that, except for these two metropolitan areas, the metropolitan area growth in the Lake Erie Basin is projected to be equal to or less than that of the nation as a whole (which for 1966-85 is 1.3%/yr.). This chiefly reflects the more mature level of urban and economic development that has already been reached in the Lake Erie Basin, particularly with respect to the large development of basic industry centered upon the coal-iron resource base of the Great Lakes Region. Moreover, the pattern of automotive and related engineering industries heavily concentrated in this Region is beginning to decentralize to other areas of the United States.[1] However, the 6 U.S. metropolitan areas on Lake Erie (see Table 4) are projected to have a total population growth of over 2 million during 1966-85, or a 26% increase for this period. This portends a substantial increase of demand for the multiple uses of the urbanized portion of the coastal zone of Lake Erie which even now is under considerable pressure.

The coastal zones of Lake Erie and Lake Superior display sharply contrasting

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1 Ross, D. Reid, and Spangler, Miller B., Higher Profits for Motor Vehicle and Parts Manufacturing in the St. Louis Region, St. Louis Regional Industrial Development Corporation, May 27, 1966, 31 pp..

TABLE 4

PROJECTED GROWTH OF U.S. METROPOLITAN AREA RESIDENT POPULATION ADJACENT TO LAKE ERIE AND LAKE SUPERIOR, 1950-85[1]
(in thousands of persons)

Resident Population - Total Figures

Area	1950	1960	1966	1975	1980	1985
United States	151,868.0	179,992.0	195,857.0	218,600	234,500	252,100
Metropolitan	85,315.4	114,166.8	131,981.1	154,700	169,900	186,100
Non-Metropolitan	66,552.6	65,825.2	63,875.9	63,900	64,600	66,000

Average Annual Rate of Growth (in percent)
Resident Population - Total Figures

Area	1950-66	1966-75	1975-80	1980-85	1966-80	1966-85
United States	1.6	1.2	1.4	1.4	1.2	1.3
Metropolitan	2.7	1.7	1.8	1.8	1.8	1.8
Non-Metropolitan	-0.2	0.0	0.1	0.4	0.0	0.1

Metropolitan Resident Population - Lake Erie

Area	1950	1960	1966	1975	1980	1985
Detroit	3,033.1	3,783.4	4,123.9	4,490	4,760	5,110
Cleveland	1,473.1	1,805.8	2,065.3	2,310	2,480	2,660
Lorain-Elyria	149.6	219.6	249.9	300	340	370
Toledo	397.0	458.6	668.7	740	780	820
Erie	220.1	251.5	254.8	280	290	310
Buffalo	1,094.2	1,307.0	1,323.5	1,500	1,600	1,710
	6,367	7,825.9	8,706.1	9,610	10,250	10,980

Average Annual Rate of Growth (in percent)
Metropolitan Resident Population - Lake Erie

Area	1950-66	1966-75	1975-80	1980-85	1966-80	1966-85
Detroit	1.9	0.9	1.1	1.4	1.0	1.1
Cleveland	2.1	1.2	1.4	1.4	1.3	1.3
Lorain-Elyria	3.2	2.1	2.0	1.8	2.1	2.0
Toledo	3.3	1.0	1.1	1.0	1.0	1.0
Erie	0.9	0.9	1.0	0.9	0.9	0.9
Buffalo	1.1	1.3	1.3	1.3	1.3	1.3

Metropolitan Resident Population - Lake Superior

Area	1950	1960	1966	1975	1980	1985
Duluth-Superior	253.3	277.2	267.6	332	376	430

Average Annual Rate of Growth (in percent)
Metropolitan Resident Population - Lake Superior

Area	1950-66	1966-75	1975-80	1980-85	1966=80	1966-85
Buluth- Superior	0.3	2.4	2.4	2.7	2.4	2.5

1 Economic and Demographic Projections for States and Metropolitan Areas, Projections to 1975, 1980, and 1985 of Population, Income and Industry Employment. Regional Economic Projections Series, Report No. 68-R-1, National Planning Association, (Washington, D. C.), January 1969, pp. S-20-24 and 148-152.

shoreline uses as seen in Figures 7 and 8. About 62% of the Lake Erie shoreline is developed for urban purposes, in comparison to 23% of the Lake Superior shoreline.[1] The contrast between Lake Erie and Lake Superior is further characterized by the intensive urban development along large portions of the shoreline of Lake Erie and the vast reaches of open coast surrounding Lake Superior. The latter is interrupted by the one fiarly large urban area at Duluth and Superior and a few lesser cities such as Ashland, Houghton, and Marquette. The waterfronts of the large urban areas of Buffalo, Erie, Cleveland, Lorain, Sandusky, Toledo, and Detroit -- as is also the case with many of the lesser cities and towns in between -- are typically heavily industrialized with high-volume port facilities and basic processing plants for raw resources. Approximately 10% of the Lake Erie Basin land area is urbanized and another 5% is used for roads, railroads, and other utilities.[2] The 62% urban shoreline frontage further emphasizes the trend that urban activity in the basin is concentrating along the shoreline. The most striking feature about the Lake Superior shoreline is the vast amount of agriculture and silvaculture, and undeveloped frontage. However, most of the hinterland to this shoreline is second growth forest lands which are nearing maturity for potential use as pulpwood and lumber. Since it is to be anticipated that timber harvesting operations will be conducted along the coastal zone and adjacent hinterland within the next 10 to 20 years,then safeguards should be established at an early date against adverse environmental impacts, especially water pollution which often accompanies this industry.

Urban development on the Canadian side of Lake Erie is less intense, with the major urban area located at Windsor (across the Detroit River from Detroit) and

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[1] Included in "urban" purposes is recreational (local/private), residential, commercial, and industrial.

[2] Water Oriented Outdoor Recreation: Lake Erie Basin. U.S. Bureau of Outdoor Recreation, Ann Arbor, Michigan, August 1966, p. 2-1.

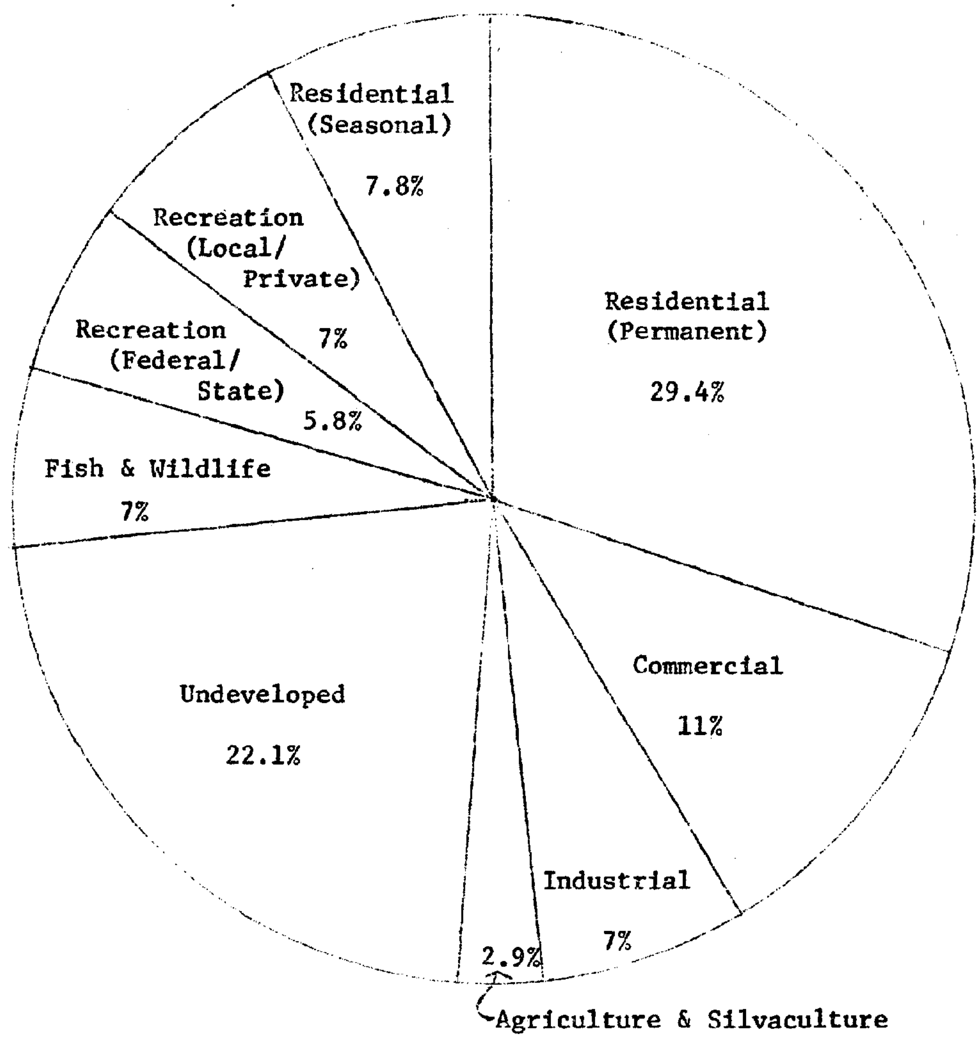

Figure 7.--The distributional pattern of shoreline use for Lake Erie in 1966

Source: U.S. Army Corps of Engineers, North Central Division, Chicago, Illinois, (See Table in Appendix F: General U.S. Shoreline Use of Lake Erie and Lake Superior 1966.)

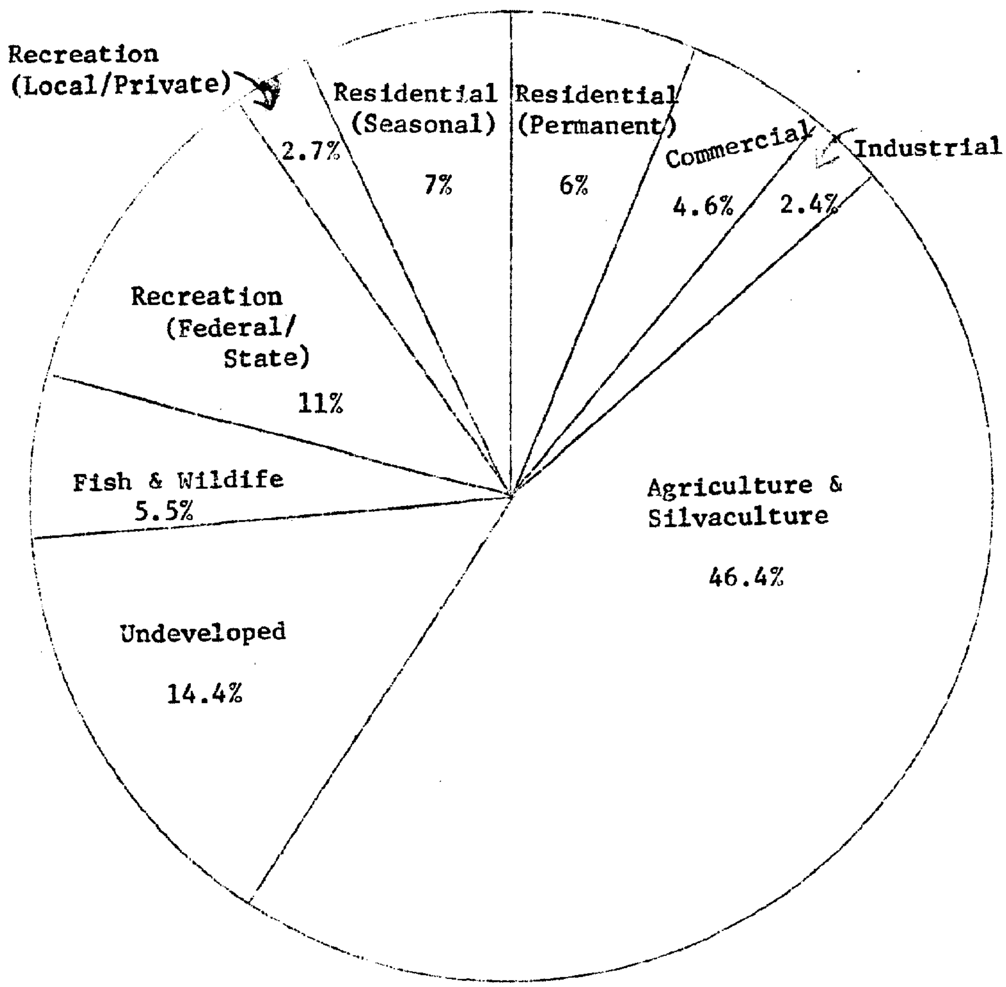

Figure 8.--The distributional pattern of shoreline use for Lake Superior in 1966.

Source: U.S. Army Corps of Engineers, North Central Division, Chicago, Illinois, (See Table in Appendix F: General U.S. Shoreline Use of Lake Erie and Lake Superior 1966.)

scattered urban development at the easterly end of Lake Erie near the Niagara River. The major Canadian urban concentration on Lake Superior is at Sault Ste. Marie. The entire Canadian population in the Great Lakes Basin totals less than 2 million; in which case, the pressure for water use and water quality management on the U.S. side of the Great Lakes Region would be on the order of 12 to 13 times higher than for the Canadian side.

Regional factors affecting use of the coastal zone.--The factors affecting growth and development in the coastal zone of Lake Erie and Lake Superior may be examined from three aspects of marine science and technology:

(1) The extent to which potential new uses of these resources can be introduced or older uses expanded through R&D efforts in the marine sciences;

(2) The extent to which R&D in the marine sciences can reduce conflict between multiple uses of these resources, or the possibilities of institutional measures or allocative decisions to reduce or eliminate socially objectionable or less desirable uses of an incompatible nature; and

(3) Achieving a balance between exploitation and conservation of coastal zone resources within a long-range planning framework.

The marked difference between the physical characteristics and the intensity of use of the shoreline of Lake Erie and Lake Superior will have an important bearing on the priorities of measures in marine science and technology affecting the optimum use of these coastal zones. It appears that the coastal zone around Lake Erie will continue to grow for the foreseeable future in population and income at a faster pace than that around Lake Superior with the exception of the Duluth-Superior metropolitan area mentioned earlier. However, the rates of growth of the respective coastal zone regions and the quality of life achieved therein will depend in large part on the manner in which the natural resources of the lakes are used -- or misused. Population and capital are in a sense renewable like many of the physical resources in the coastal zone. Misuse of human and capital resources can often be corrected, as is the case of misuse of renewable physical resources. The idea of applying conservation to the use of nonrenewable resources is reasonably well understood. After these are once used or abused, recovery is almost impossible. However, as renewable resources are taxed beyond their ability to restore themselves at the level of maximum sustainable yields -- such as soil erosion, timber cutting, or the filtering and purifying action of a stream -- they begin to take on the characteristic of nonrenewable resources. This means that in the classical sense of "land, labor, and capital" providing the foundation for growth and development in the coastal zone, the intensive demands being placed on the physical resources in the coastal zone of Lake Erie has virtually thrust many elements of the resource system -- such as the water supply -- into the category of a nonrenewable resource. Unless remedial action is taken to re-establish certain natural relationships and balance including the human activities conducted within these balances (even if artifically established and maintained), severe limits may be placed on the economic growth of the region as well as the more restricted coastal zone of Lake Erie. This problem is compounded by the nature of political, social, and economic realities which often do not admit of the partial regeneration of certain natural resources -- including aspects of eutrophication -- even where such might be (or become) technologically feasible.

To examine in greater detail the factors affecting the use of coastal zone resources requires an additional distillation of uses based upon their impact on the coastal zone environment. From this organization of coastal zone uses, measures in marine science and technology for achieving optimum use may be derived, as has been done in the analysis in Part III.

Another transition is occurring in the urban waterfront areas of the coastal zone, particularly along Lake Erie. While at the same time competition for port facility development is increasing, as discussed in the following section on Transportation, demand for waterfront land for general industrial use appears to be decreasing. This is, in large part, due to the competition for relocating non-water oriented industry closer to hinterland market centers and along other transportation system modes. As these industries still require transshipping facilities in many parts of the Great Lakes, along with the growth of domestic and foreign trade, major port development programs have been initiated at Cleveland and Toledo -- to name just two examples.

The shifting of industrial land demands from waterfront properties has resulted in the underutilization and actual abandonment of what appears to have been numerous wharf and dock facilities and waterfront sites for defunct industry. These spaces offer opportunity (if these can be made available) for rehabilitation for expansion of water-oriented industries and transshipping facilities -- reducing the need for additional filling of large tracts or expensive redevelopment of other urban uses.

Also associated with the possible availability of some of industrial lands, which had heretofore had priority use of the shoreline because of the economics of industrial land values and early dependence on water transportation, is demand for recreation and residential use. This demand is being exploited by many local authorities to develop waterfront areas, both through utilizing land that can effectively meet certain residential land and recreation access needs, as well as attempting to reconstruct economic activity on these derelict waterfront lands.

There are at least two factors which appear to inhibit significantly the progress in the transition of residential and recreational use of waterfront lands. The first is that many of these lands are still fairly expensive. The central city housing market near where these waterfront sites are becoming available reflects the two extremes of high-income families and moderate to low-income families. Consequent provision of high-rise apartments for lower income housing has not proved successful without relatively extensive construction costs or rent-subsidy programs. On the other hand, high-quality housing facilities for higher income markets are better able to demonstrate economic feasibility and are becoming a more prevalent occurrence. In either case, the only progress which has been made or contemplated in the near future in the relatively large-scale redevelopment of urban waterfront areas -- other than specific port authority projects -- involves the assistance of Federal urban redevelopment program funds. This raises the question of social equity associated with using public monies to encourage the development of economic enterprises or to respond to other current social needs in these urban waterfront areas. This latter question already has been subject to considerable debate within the Federal urban redevelopment program, and is one which will need to be considered in the development of program objectives for use of waterfront resources within the context of a marine sciences program.

The second factor which appears to be a significant inhibitor to the waterfront redevelopment is water pollution. There were many beaches which have been completely abandoned because of pollution. Additionally, the unique aesthetic and recreational qualities of the shoreline and river banks -- adjacent to the aforementioned residential developments, for instance -- were not fully utilized. Little or no particular attention was given to treating the landscape or development of the aesthetic qualities, or providing access to the water for direct human use, such as swimming. An exception was marinas which were frequently encountered in these development projects. The fact that the pollution was there, and had been there for some time, and that pessimistic attitudes prevail with regard to pollution abatement in the foreseeable future, fosters an attitude of discouragement over the treatment of waterfront development for human access to the water.[1] Indeed, it would appear

[1] For a brief review of the pollution and the popular attitudes associated with the problem, see: "Blighted Great Lakes", pp. 36-45, and "Sewage Gushes On, But Something Is Being Done", Richard Woodbury, pp. 46-47, *Life*, August 23, 1968.

that,should pollution along these shoreline and rivers be effectively abated, demand for waterfront access would cause a new flourishing of development activity and land use pressures.

An observation relative to the concept of "conflicting use" deserves mention. Along the U.S. shore of Lake Erie, one encounters a number of small marinas and parks, or simply vacant spots which have reverted back to a wildland state. These sites were found sometimes delicately nestled in a corner of a large port facility, or between two large ore boat slips, or next to a huge iron ore and coal unloading and storage facility. Normally, one would not consider these uses "compatible". But whether by accident or ingenious design, these appeared to add an interesting and refreshing variety to the urban waterfront landscape; as well as appearing to be successfully integrated with the surrounding uses These examples remind us that in the grand schemes of designing broad institutional frameworks to effectively segregate conflicting uses of the shoreline , there should be sufficient flexibility to promote thoughtful and well-designed exceptions.

On the basis of their impact on the coastal zone, the present and potential uses of the coastal zone of Lakes Erie and Superior may be generally categorized as follows:

(1) Uses of the lake waters and resources of the lake, lake bed, and sub-floor:

- Fresh water supplies for municipal, industrial, and utility uses, including agricultural needs,
- Hydroelectric generation (flows),
- Receptacle for waster substances (liquid and solid),
- Transportation (shipping and navigation),
- Extractive uses (commercial and sport fishing, aquatic plant harvesting, sand and aggregate minerals for construction, oil and gas);
- Recreation (aesthetics, boating, swimming, and fishing);

(2) Water-oriented uses of the coastal margin:

- o Extractive industry base (fish-processing plants, mineral extraction plants and spoil banks, and aquatic plant harvesting bases),
- o Water-oriented industry (shipbuilding and repair, port facilities and rescue services, warehousing, and manufacturing and processing),
- o Utilities (power plants, water supply intakes, sewage treatment plants),
- o Recreation (beaches, resorts, recreation-oriented residential uses, parks and other open spaces),
- o Marine research institutions,
- o Urban uses (waterfront housing, waterfront commercial),
- o Agriculture (speciality crops such as vineyards and fruits),
- o Wildlife conservation areas;

(3) Nonwater-oriented uses of the coastal land margin:

- o Urban (commercial, residential, public and institutional, and utilities),
- o Transportation facilities,
- o Industrial,
- o Agricultural,
- o Open space (parks, recreation areas, flood plains, other public and private reserves),
- o Unclassified or undeveloped.

For purposes of distilling measures in marine science and technology for achieving optimum level of use in the above categories of coastal zone use, the following organization was developed for use in this study:

(1) Water quality and control: (a) eutrophication and algal growth; (b) measurement of pollution and effects; and (c) pollution controls and waste management by sources.

(2) Modifications of the coastal zone: (a) land fills; (b) dredging and excavation;(c) shoreline erosion and protection; (d) port and harbor development.

(3) Social and economic uses of the coastal zone: (a) transportation; (b) recreation; (c) commercial fisheries; (d) mineral resources; (e) agriculture and forestry; (f) industrial development; (g) urban development; (h) power development; and (i) water resource mangement.

It should be noted that some of the factors affecting use of the coastal zone and the measures for marine science and technology discussed in the following section will have general applicability to all of the Great Lakes -- or even to the United States or the world at large, as in industrial water and air pollution. Others will be tailored to the more or less unique aspects of Lake Erie or Lake Superior. Moreover, some of the required research will be in the field of the social sciences. This is particularly important with respect to planning analysis and research measures since the interaction between man and the environment of Lakes Erie and Superior involves the problem of goal-setting in resource development and the resolution of conflict situations in resource utilization.

It has been possible to explore only a fraction of the complex relationships of man and the marine enviornment in a work of this level of effort. The selection of key items for analysis has been made on the basis of reveiw of the literature; interviews with public officials, scientists, engineers, and technicians of government and industry; the use of project consultants residing in the region; and the judgment of the contractor, whose experience was broadened by an extensive field survey of the study area. The final portion of this study includes a brief discussion of a methodology and criteria for further refining the selection process for identifying priority measures in marine science and technology needed in the coastal zone.

REVIEW OF PROGRAM REQUIREMENTS TO SUPPORT OPTIMUM USE

Water Quality and Control

Overall environment policy.--The rising national concern over maintaining and, in many cases, restoring the quality of the environment provides the basis for emphasizing actions for enhancing the quality of the coastal zone environment around Lakes Erie and Superior. In this regard, Senator Muskie states:[1]

> A new philosophy in directing the nation's efforts for a clean and healthy environment is shown in both the Water Quality Act of 1965 and the Air Quality Act of 1967. Pursuant to those laws, the Federal Government supplies leadership and creative resources, as well as research and construction funding. The states retain the primary responsibility for developing water and air quality standards. Federal law provides a framework around which the states can organize their pollution control efforts and mechanisms by which their goals can be implemented. In essence, these laws have stimulated meaningful state control programs.

Similarly, a report of the Task Force on Environmental Health and Related Problems spelled out in June 1967 a series of 10 goals to provide for the optimum health of the American people which has particular significance to the coastal zone environment of Lake Erie. The Task Force recommended that the Department of HEW ensure that every American can thrive in an attractive, comfortable, convenient, and healthy environment by: (1) controlling pollution at its source, (2) reducing hazards, (3) converting waste to use, and (4) improving the aesthetic value of man's surroundings.[2] The Task Force on Environmental Health and Related Problems also recommended 10 action goals for environmental quality:[3]

Goal 1: An air quality restoration effort to initiate by 1970 in 75 interstate areas, abatement plans to reduce plant stack emissions by 90%

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1 Muskie, Edmund S., "The Challenge of Pollution Control: Where We Stand", Chemical Engineering, October 14, 1968, p. 17.

2 A Strategy for a Livable Environment, U.S. Department of Health, Education, and Welfare, Washington, D. C., June 1967, p. xv.

3 Ibid., xvi-xvii.

and to establish national standards to reduce vehicle exhaust emissions by 90% from 1967 levels through enforcement, and a technological development program to provide the equipment necessary to meet the standards.

Goal 2: A water quality effort by 1970 to test all existing and proposed public drinking water supply systems and produce meaningful public drinking water standards which, through an enforcement program, will ensure health-approved drinking water for 100% of the Nation's public systems.

Goal 3: A waste disposal effort to provide by 1973 a grant-in-aid program for solid waste disposal at the local level; developmental research program to integrate solid and liquid waste disposal and air quality control; and for the disposal of nuclear wastes.

Goal 4: A population research effort to determine by 1968 the effects of population trends on environmental protection goals and programs as part of the basis for setting departmental objectives with respect to family planning and population dynamics.

Goal 5: An urban improvement effort to develop by 1973 through research basic data sufficient to establish human levels of tolerance for crowding, congestion, noise, odor, and specific human endurance data for general stress and accident threats, including traffic, home, and recreation accidents.

Goal 6: A materials, trace metals, and chemicals control effort to establish by 1970 human safety levels for synthetic materials, trace metals, and chemicals currently in use and prohibit after 1970 general use of any new synthetic material, trace metal, or chemical until approved by the Department of Health, Education, and Welfare.

Goal 7: A consumer protection effort which by 1970 will initiate a comprehensive program for the identification of health and safety hazards associated with the use of appliances, clothing, food, hazardous substances, and other consumer products and for the control of such products which fail to meet consumer protection standards established by the Department.

Goal 8: A radiation control effort which by 1970 through developmental research and enforcement adequately protects workers and the public from harmful radiation levels.

Goal 9: An occupational disease and safety protection effort to extend by 1970 preventive services to 100% of the employed population at its work place.

Goal 10: A governmental compliance effort which by 1969 through effective relations with local, state, and Federal governments will ensure that criteria and standards for physical and mental health for housing, urban development, and transportation will be available and used by the Federal agencies administering these programs.

Goals 1, 2, 3, 5, 8, and 10 are particularly significant to this study because they deal with areas of concern to the marine sciences with respect to the manner in which the coastal zone is developed. Along the lines of the specific strategy recommendations of the Task Force on Environmental Health and Related Problems, included in Appendix C, an Institute of Environmental Health Science has been set up in the Department of Health, Education, and Welfare with two major missions: (1) to find the size and meaning of hazards to human health inherent in long-term exposure to low-level concentration of biological, chemical, and physical environmental agents; and (2) to study the adverse effects with the hope that principles related to this response can be established as a scientific base for criteria on which to set standards and to provide predictive guides to be used by control agencies for protective or preventive measures.[1] These are,indeed,roles that need to be played in the coastal zone. Other steps called for by the Task Force have been taken in the Great Lakes by other agencies, such as the FWPCA follow-through on cooperation with states around Lake Erie in setting and achieving water quality control standards by 1972.

A Presidential Task Force on Resources and the Environment in early 1969[2] urged that improved environmental management be made a principal objective of the new Administration because "the real stake is man's own survival -- in a world worth living in", and stressed the need to improve "the declining environmental quality of our urban areas" where most of the population lives. This objective expresses

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[1] Air & Water News, January 20, 1969, p. 4.

[2] "Nixon Panel Reports on Environment", Science, February 7, 1969, p. 549.

the need for environmental improvement around Lake Erie shoreline. While the Task Force concluded that "the present fragmentation, piecemeal approach, inadequate coordination, and lack of central policy direction and control of environmental programs constitute an obstacle to their effective implementation", it did not suggest any panaceas or mammoth new programs or any major reorganization of government programs without a thorough study. The Task Force called for four major steps: (1) that the President appoint a Special Assistant for Environmental Affairs who would serve as a "focal point" for the Government's scattered environmental concerns and who "would evidence dramatically the new Administration's concern for a better environment"; (2) that the present interagency Council on Recreation and Natural Beauty should be broadened into a Council on the Environment with the Vice President continuing as Chairman; (3) that each Federal agency whose program activities significantly affect the environment, such as highway construction, should establish a "focal point of environmental responsibility" to take into account the side effects -- such as air pollution -- which are the program responsibility of completely separate agencies; and (4) that existing programs be made to work better through greatly increased appropriations, better corrdination, new regional approaches, and a strengthened role for industry and for state and local governments. Considerable actions to carry out these similar goals for environmental protection are already being taken. For example, numerous lakeside communities have programs to improve sewage treatment and to extend treated sewage discharge pipes a greater distance from shore reducing pollution and algal growth in nearshore waters. Various industrial plants have also undertaken projects to curb pollutants being discharged into the lake. A major program has been initiated by Cleveland involving a large sewer and treatment plant construction program, and in cooperation with the FWPCA, is exploring alternative methods for waste water disposal. The State of Wisconsin in 1965 enacted a comprehensive water resource program which provides for coordinated flood plain and shoreline zoning and in providing incentive to industry to solve its part of the pollution problem. Also, the Department of Interior has established a Branch of Urban Affairs in the Bureau of Sport Fisheries and Wildlife; and an Office of Environmental Impact has been established in the Department of Transportation. From the Federal viewpoint, the responsiveness to environmental problems which these offices can provide their parent organizations needs to be specifically directed at the operational programs which these agencies conduct in the Great Lakes Region.

In April 1969, President Nixon announced his intention to establish by executive order a cabinet-level Environmental Quality Council composed of the President and the Vice President, and the Secretaries of Agriculture; Health, Education, and Welfare; Housing and Urban Development; Interior; and Transportation. The establishment of the Environmental Quality Council is part of the announced Administration's commitment to "a national policy of defining in law the rights of Americans to have clean air, clean water, and other ingredients of a healthy environment."[1] The question has not been decided as to what direction will be taken to restructure the government in order to implement the declaration, particularly in view of congressional interests in an independent Council on Environmental Quality as well as an independent environmental surveillance group to forecast troubles such as air and water pollution stemming from technological advances. It has been suggested that such an analytical body be formed around the science policy group in the Library of Congress and provide an independent check on the controversial projections on environmental impact provided by various sources. It has also been suggested that

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1 Mintz, Morton, "Environmental Council Planned", The Washington Post, April 17, 1969, Washington, D. C., p. A-2.

the analytical body be conceptually organized as a fourth body of government purely for the purpose of analysis and review that is independent of the courts, Congress, and the Executive Branch.[1]

The issue of protecting the environment at this time appears to be a combination of political constituencies, governmental administration, and determination of accurate scientific information upon which judgmental decisions may be made on environmental policy, regulation, and action programs. It is not in the purview of this study to re-examine national objectives on environmental quality; however, it is of key concern that the application of national objectives on a regional and local basis will reflect considerable differentiation in policy and program actions from one area to another. National objectives on environmental quality will provide guidelines for setting priorities for water and air quality control measures in the Great Lakes; but certainly priorities will vary, say, between the Lake Erie Basin and the Lake Superior Basin. In this instance, emphasis would be placed on preventative measures in the Lake Superior Basin and restorative measures emphasized in Lake Erie. The key question in this context is "Where will the decision be made for regional application of environmental policy?" The mechanism is evolving in the Great Lakes through the Great Lakes Basin Commission to coordinate Federal, state, and local interests in environmental control measures in response to a "national commitment" for preserving environmental quality.

This, in turn, raises new questions: "Can the Great Lakes Basin Commission develop the political constituency to carry out effectively a national commitment in its region? Can the Great Lakes Basin Commission organize effectively to coordinate the follow-through on environmental policy? Can adequate scientific data

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1 Air & Water News, March 10, 1969, p. 6.

and expertise be made available to facilitate decisions to do the job in the face of conflicting interests and an atmosphere of controversy?"

While the desirability of the Great Lakes Basin Commission playing a role in coordinating regional planning and decison-making was discussed earlier, the answer to the above questions are still to be resolved. As mentioned, individual Federal agencies, individual states, and local areas have become concerned with various aspects of environmental quality and have taken large steps toward environmental protection measures; however, these efforts are still largely organized and supported on an individual jurisdictional or functional basis. While popular support appears to be growing for the Great Lakes Basin Commission, it does not yet appear to be playing a significant role in tying together voluntarily committed coordinated efforts to rally the critical mass of effort that it is really going to take to "Save Lake Erie" or "Preserve Lake Superior" -- assuming these become operational regional objectives. As the advantages of regional cooperation become accepted -- as well as being recognized as "needs" -- in state and local areas, the outlook will substantially improve for the Great Lakes Basin Commission (and the other regional organizations which may become affiliated with the concerted process) to become an effective agent to establish and to spark the accomplishment of regional goals.

Waste management in the coastal zone.--The problem of water quality needs to be examined in the context of an overall waste management regime for the densely populated coastal zone of Lake Erie. According to a recent Massachusetts Institute of Technology study, about 5 pounds of solid refuse accumulate per person each day.[1] Accordingly, roughly 21,000 tons of refuse emanate daily from the major metropolitan areas around Lake Erie. As coastal zone population continues to expand

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1 "Waste Disposal Field Alive With New Ideas", Nation's Cities, December 1968, p. 28.

and as onland sites for disposal of solid wastes diminishes, it can be seen how the lake itself will become increasingly attractive as a convenient receptacle for these wastes. Suggestions for new approaches to waste management include the following:[1]

- Small towns (as well as metropolitan areas) could cut costs by using regional plants to dispose of refuse. Ten times as much waste could be handled at half the cost in the cyoperative manner.
- Silent crushers, which look like concrete mixers, could make household collections.
- Trash could be used to fill low land along highway shoulders and, thus, reduce accidents.
- Salvagable materials such as paper, rags, glass, and metals could be resold to industry and leftover refuse used as compost.
- Empty shafts and open pit mines could be used as sanitary land fill sites.
- The use of no-deposit, no-return packaging in certain products could be prohibited.

Some of these approaches are already being explored by government and industry in the coastal zone of Lake Erie and Lake Superior. For example, a coal pipeline is being tested for pumping solid wastes from Cleveland to a strip mine 100 miles away.[2] The City of Cleveland is also investigating the possibility of solving several of its waste disposal problems while putting a new product in the hands of engineers charged with reclaiming submerged lands in Lake Erie. The idea is to compact bricks from various waste materials and use them to build dams and retaining walls for under-lake structures, such as an extension of the Lake Front Airport runways or an addition to Westerly sewerage treatment plant which is to be built on a man-made island in Lake Erie.[3] Another idea is to design large-scale production ponds

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1 Ibid..

2 Air & Water News, January 27, 1969, p. 4.

3 Ibid..

to cultivate algae on wastes. The algae may be a promising protein supplement for livestock feeds. Current estimates are that algae grown on waste will cost about 6¢ per pound dry weight[1], which is less than half the cost of other sources of feed grade animal protein supplement.

Another problem is the difficulty in management of industrial wastes. However, R&D in some of the most difficult of industrial waste management problems is already proving successful. For instance, it has been found that mixing acid mine drainage waters with sewage effluent under certain conditions has significant advantages in treating both types of waste streams.[2] Bringing these two types of waste streams together: (1) brings the acidity of the mine drainage water down to acceptable levels, (2) reduces by as much as 98% the iron salts which contribute to the acidity and discoloration of the water, and (3) significantly reduces the phosphate content of the sewage effluent. The method could be incorporated into conventional sewage treatment plants with no major new investments and no loss in treatment capacity. Moreover, studies have shown that the flocculating properties of the ferrous precipitates produced may increase the efficiency of certain treatment steps to the extent that actual increases in capacity could result.[3] Although no specific application of this technique is known in the Great Lakes Region, this principle could possibly be applied to the conveyance of various industrial wastes through municipal treatment systems. In the design of individual industrial waste treatment systems,

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1 Oswald, Wilbain J.; Golveke, Clarence G.; and Cooper, Robert C., "Designing for Large-Scale Algae Production From Waste", Paper presented at the 41st Annual Conference of the Water Pollution Control Fed,September 22-27, 1968, Chicago, Illinois, Water Pollution Control Administration, Washington, D. C..

2 "Mixing Sewage With Acid Mine Water Solves Two Problems", Environmental Science and Technology, Vol. 2, No. 9, September 1968, p. 655.

3 Ibid..

waste materials that can be neutralized with municipal sewage materials could be directed into the municipal systems, with possible savings accruing to both the industrial treatment system -- by way of capital savings -- and the municipal system in terms of enhanced efficiency in achieving water quality goals for the area and helping to speed industry along in doing it job.

Air pollution control in the coastal zone.--Air pollution is becoming an increasing problem around the major metropolitan areas along Lake Erie. The first major effort to develop regional air pollution abatement programs was initiated with the enactment of the Clean Air Act of 1963. This Act established provisions for Federal financial assistance to state and local agencies for developing, establishing, or improving air pollution control programs. All of the states contiguous to Lakes Erie and Superior have enacted air pollution measures which are summarized in Appendix D. The Air Quality Act of 1967 went further in calling specifically for a regional approach to the control of air pollution in four principal areas:[1]

- Establishment of criteria of ambient air quality which describe scientifically the effects on health and welfare for varying concentrations of a contaminant, or contaminants, under different atmospheric conditions.
- Setting of enforceable ambient air quality standards based upon the air quality criteria.
- Development of plans for air quality control regions, to implement the established ambient air standards giving due consideration to factors of technical and economic feasibility.
- Provision of required stimuli to industry and government to improve emission control technology to the degree required to prevent and abate air pollution.

Senator Muskie also states in this regard:[2]

The Air Quality Act emphasizes maximum state participation in air pollution

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1 Goulding, Clark L., "Regional Approach to Air Pollution Abatement Gains Momentum", Environmental Science and Technology, May 1969, pp. 431-434.

2 Muskie, op. cit., p. 17.

control, but does not deal in detail with the concept of political organization for an air quality control region. In order to be effective, an interstate regional authority must have all of the legislative authority vested in the participant state agencies, plus a sufficient delegation of sovereignty to operate effectively.

It may be that a new kind of regional agency is required to perform the type of police action needed by the Act, perhaps some new and flexible combination of jurisdictional and institutional arrangements.

Air quality control regions have been designated at Detroit and Toledo, and designation is imminent for Cleveland and Buffalo by the National Air Pollution Control Administration. The designation of air quality control regions is part of a complex, but carefully designed, system ultimately involving the private sector as well as all levels of government.[1] These air quality control regions were designated on the basis of the severity of the problem; and it is the NAPCA hope that once the states experience the benefits of approaching air pollution on a regional basis, they will adopt on their own initiative regional approaches to conservation of the region' air resources. The NAPCA will encourage states not only to develop air pollution programs on a regional basis, but also to propose to us boundaries for those areas they think should be formally designated as air quality control regions.

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1 Goulding, op. cit., p. 432. In addition to designating air quality control regions, the Secretary of Health, Education, and Welfare (HEW) issues air quality criteria and reports on control techniques. For each pollutant covered by the requisite criteria and control technology documents, every state involved in a designated air quality control region must set an air quality standard for that pollutant and develop a plan by which the standard will be implemented. Each state notifies the Secretary of HEW of its intent to develop a plan within 90 days of the issuance of the two documents, or its intent to designate a region, whichever comes last. Then, each state has six months to set air quality standards and another six months to develop an implementation plan. This process meets the first 3 points outlined above. Expanded research responsibilities, the fourth point, along with the first three, are the heart of the Air Quality Act of 1967. This process is also backed up with authority of the HEW Secretary to take appropriate action in cases where the above sequence breaks down. The above procedure, as well as NAPCA's related administrative policies, is described in detail in a forthcoming publication entitled, "Guideline for the Development of Air Quality Standards and Implementation Plans". Bridging the gap between the responsibilities of NAPCA and those of the states, the document will be essential to success of the Air Quality Act.

Local jurisdictions are also beginning to take firm steps to elevate air pollution. Cleveland, for instance, is developing a tougher air pollution law and intends to spend nearly $2 million on the city's control program over the next three years. New regulations will include particulate emission limits and limits on sulfur as SO_2. The Mayor of Cleveland stated:[1]

> In the past, the city's ability to cope with industrial red dust and other air pollutants has been so unworkable that since air pollution laws were first put on the books in 1926 not a single violator has ever been brought to court.

Local control also enables a flexibility in tailoring programs so they may be easily altered to fit new needs.[2]

The discipline and programs in the marine science concerned with meteorology; the land, air, sea interaction; and environmental monitoring systems should be involved in the process of designating air quality control regions, analyzing the basic data on air quality, and setting the objectives and standards for air quality in the coastal zone region.

Implications for national programs in water quality control.--With respect to water quality problems, the nation has embarked on a program comprising a number of basic elements:[3]

(1) Establishment of water quality standards throughout the country.

(2) Creation of regional plans to anticipate and meet the future water needs of vast metropolitan growth.

(3) Sharp increases in Federal aid to municipalities for construction of waste treatment plants.

(4) A new awareness of the vital importance of accelerating research in the water pollution field and strong Federal support for this research.

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[1] Air & Water News, April 21, 1969, p. 4.

[2] Chass, Robert L., "Control at the Local Level", Chemical Engineering, October 14, 1968, p. 22.

[3] Jones, Robert E., "Pollution: How the Federal Act Will Help Bring Clean Waters", Nation's Cities, March 1967, pp. 36-37.

(5) A tougher attitude toward the industrial pollutor.

(6) Increased emphasis on the concept of Federal, state, and local partnership in the task to get clean water.

The Water Quality Act of 1965 is the basic action tool for this program. The Act places upon the states the initiative for setting water quality standards for the portions of interstate rivers within their boundaries. If they fail to do so, the Federal Government has indicated it will do it for them. Establishment of water quality standards will provide the guidelines for preventive, not simply remedial, action. Once the standards are set, municipalities and industries may develop realistic plans for new or expanded treatment facilities with greatly reduced uncertainty about waste disposal requirements.

The growth of population and economic development will put further pressure on the Great Lakes for a source of fresh water and as a receptacle for the waste by-products of this growth process. The preservation of the quality of water for these purposes involves two complex and interrelated webs: an ecological web of chemical and biological causal links, and a social web of user activities.

Waterborne waste disposal methods in use today are based upon the biological processes in natural waters that can break down wastes into their basic organic nutrients or dilute inorganic materials so they are harmless. The Great Lakes and their tributaries and connecting channels have provided an inexpensive and convenient waste disposal system. Because of the large capacity of the Great Lakes system, it was not until recent years that the great increases in waste effluent discharges (i.e., the return of water to the system at a lower quality level than that which was taken in) began to overload the natural biological system with the resulting consequences of pollution. Lake Erie is the most dramatic example of these consequences and is often referred to as becoming a "dead" lake -- although it is still highly productive of trash fish and certain other aquatic life.

Waterborne waste inputs to Lake Erie have come from three primary sources: (1) waste effluents of toxic or offensive materials from industrial processes; (2) municipal treatment plant effluents which are largely treated to "secondary" standards; and (3) fertilizer and pesticide runoff into waterways from their increased use in agricultural production. Water polluting substances may be classified into eight general categories, each of which is somewhat unique in pollutional characteristics and effects: (1) oxygen demanding wastes, (2) infectious agents, (3) plant nutrients, (4) synthetic organic erotics, (5) inorganic chemical and mineral substances, (6) sediments, (7) radioactive substances, and (8) heat.[1]

Goals for water quality programming in the Great Lakes include:[2]

- Reduction of waste loading as much as possible since the waters of the Great Lakes are the final recipients of the waste and used waters from the watershed.
- Aesthetically acceptable waters, not offensive to touch, taste, sight, or smell.
- Consistently high quality water for domestic, agricultural, and industrial use.
- A healthy commercial fishery.
- A balanced ecological environment providing proper protection for fish and wildlife.
- Enhanced recreational use for boating, fishing, and water contact activities.
- Responsible use of the waters for waste disposal.
- Continuing development of navigation and power use.

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1 A description of these pollution substances and their pollutional characteristics is included in Appendix B.

2 Hennigan, Robert D., "Water Quality in the Great Lakes: Costs and Cost Sharing to Meet Water Quality Goals", A paper presented at the Great Lakes Water Resources Conference, Toronto, Canada, June 24-26, 1968, State University of New York, Syracuse (Unpublished).

Eutrophication[1] is one of the major problems associated with water pollution, particularly in Lake Erie. The effluents form agricultural fertilizer;and municipal wastes subject to secondary treatment are largely basic nutrients such as phosphates, nitrates, and other trace elements. This nutrient enrichment accelerates the process of eutrophication which even in natural circumstances is not totally avoidable. The nutrients which enter the lake from agricultural fertilizer runoff and urban waste treatment plants stimulate algal growth and further biological production. This process may sometimes be beneficial in increasing the yield of certain kinds of trash fish and perhaps could be steered to produce a valuable algae for food or drug production. Algal growth has occurred in such quantities as to be a nuisance in the form of gathering algae on beaches and consuming oxygen in water and killing fish. A major requirement of the Water Quality Act of 1965 is the universal application of secondary treatment of municipal wastes and the acceptance of comparable standards by industry.

Chemical and other inorganic materials from industrial effluences are, for the most part, stable pollutants. These can principally be rendered harmless if adequately diluted. Agricultural pesticides entering the lakes have a more subtle, and perhaps more disturbing, effect on the water. For instance, they may accumulate in some aquatic organisms and pass through fish and fish-eating birds and lead to infertility and even death. The accumulation of DDT in eggs now threatens the spectacularly successful coho salmon fishery,and pesticides in Lake Superior are a

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1 "Eutrophication" is a process involved in the natural aging of a lake which is characterized by high rates of algal growth stimulated by nutrient enrichment of the lake and resulting in seasonal oxygen deficiencies and promoting shallowness over millenia of years. Whenever man-made wastes or nutrients are added, this can greatly accelerate the natural process as already has happened in Lake Erie.

threat to the population of certain species of fish-eating eagles.[1]

There is now a great range in the water quality between Lake Erie and Lake Superior. Changes will depend to a large degree on the population pressure in the watershed -- both in terms of the Great Lakes drainage basin system as a whole and the respective watersheds for each lake, such as Lake Erie and Lake Superior. In each of these two basins, there is considerable difference in quality between near-shore and offshore waters, which may persist for much of the time. This is particularly true for Lake Erie in its shallower, western end. Differences may appear between inshore and offshore, as well as from the western end of the lake to the eastern end. The mechanism of exchange between inshore and offshore water requires further study -- and in the case of Lake Erie, lake circulation from one end to the other.[2]

It may be assumed that the trends of population growth (especially concentration in the coastal zone),increasing urban and industrial development, and the corresponding increase of waste by-products will continue. However, the present pattern of waterborne waste disposal will need to be controlled or managed within the load limits of the lake's system. Otherwise, the continuation of the processes of eutrophication and pollution -- especially in Lake Erie -- will curtain the availability of water of adequate quality to support use and reuse.

Remedial measures to restrain pollution and, hence, eutrophication will largely involve the following systems which are still experimental and highly conjectural:

(1) Introduction of tertiary waste treatment. This level of sewage treatment involves removal of phosphates and other growth promoters -- some of which

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1 However, the State of Michigan has taken conservationist measures to mitigate this threat through certain controls of the types of pesticides used in the region.

2 Mortimer, C. H., "The Great Lakes: General Characteristics, Multiple Uses, University Involvement", a paper presented at a hearing of the Great Lakes Panel of the National Council on Marine Resources and Engineering Development, Ann Arbor, Mich., October 29, 1968.

are in extreme dilution. The process is expensive and difficult.

(2) Controlling water quantity in lake levels and flows to dilute and transport waste materials to the ocean.

(3) The use of other disposal systems involving other than lake-oriented waterborne disposal systems.

a. Export of water out of the basin, such as using a large trunk collector along the axis of the megalopolis.

b. Complete oxidation of the solid particles in liquid wastes at temperatures and beyond present technology, indusing renewal of pure water as a by-product, and final disposal of waste remains in underground receptacles.[1] (Other reusable products may be reclaimed).

c. Chemical decomposition, oxidation, or neutralization of waste materials.

d. Straining and precipitator devices -- using physical sraining and filtering materials, electronic precipitator, or chemical additives.

With particular regard to the magnitude of pollution problems in Lake Erie, Dr. Robert A. Sweeney states that the lake is not a "dead lake", as it has been frequently misdescribed in numerous newspapers and magazines.[2] Today Lake Erie is more productive, in terms of the numbers of aquatic organisms, than at any time in its history.[3] However, in many cases, the types of plants and animals that presently are flourishing are considered undesirable by many individuals. It is not believed possible to turn back the "ecological clock" and recreate the lake conditions that existed in 1900. However, through R&D, it may be possible to utilize this fertile lake for more desirable ends.

The adjective "dead" was first applied to Lake Erie following the rapid demise

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1 Air & Water News, September 16, 1968, p. 5.

2 Russell, Roland, "Lake Erie: Old Before Its Time", Buffalo Evening News, December 1967.

3 Brinkhurst, Ralph O., "Change in the Benthos of Lakes Erie and Ontario", Changes in the Biota of Lakes Erie and Ontario, Buffalo Museum of Science, 1969 (in press).

of the lake's commercial fishing industry. These losses were primarily due to the disappearance of such fish as the cisco (Coregonus artedii), whitefish (Coregonus clupeaformis) and walleye or yellow pike (Stizostedion vitreum). These species were replaced by the carp (Cyprinus carpio) and sheepshead (Aplodinotus grunniens).[1] Presently, the latter two fish have little commercial value. However, if the techniques for extracting fish protein concentrate (fish flour) from "oily" fish, such as the carp and sheephead, were developed, Lake Erie could provide a vast supply of such protein.[2] Dr. Robert Sweeney notes that a Canadian firm exploits trash fish from Lake Ontario for fish meal used as pet food.[3]

The development and introduction of marketable fish that are more tolerant of the present environmental conditions could revitalize the lake's commercial fishing industry. The success of the coho salmon (Oncorhynchus Kisutch) in Lake Michigan exemplifies what can be accomplished through such efforts. Commercial and sport fisheries both would be improved if more effective techniques were developed to remove and/or degradate organic industrial wastes prior to their entering Lake Erie. These chemicals, such as phenols, cause the fish to have a poor taste.[4] If such desirable flavors were absent, a considerable smoked fish industry could be initiated.

Another aspect of the pollution problem that is in need of R&D concerns recreation. With higher wages and shorter work weeks, there has been a 300% increase in

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1 Baldwin, Norman S., and Saalfeld, Robert W., Commercial Fish Production in the Great Lakes 1867-1960, Great Lakes Fishery Commission Technical Report No.3, Ann Arbor, Michigan, 1962.

2 March, B.E., et. al., "Composition and Nutritive Value of Meals From Alewife, Sheepshead, Maria, and Tullibee", Journal of the Fisheries Research Board of Canada, Vol. 21, No. 6, 1967.

3 By personal communication.

4 McKee, Jack E., and Wolf, Harold W., Water Quality Criteria, California State Water Quality Control Board Publication No. 3-A, Sacramento, California, 1963.

the number of pleasure craft owners in the Lake Erie Basin during the past twenty years.[1] An even larger increase has been observed in the numbers of individuals who partake in fishing and swimming. However, the number of days that Lake Erie's beaches and boat launching sites are open each year is decreasing. Such closings primarily have been caused by the recent proliferation of "lake moss" or Cladophora.[2] This shoreline algae chokes the beaches and clogs engines. The putrid stench from rotting masses along the shore also reduced the value of lakeside land. Increasing Cladophora problems are believed to exist on Lakes Michigan and Ontario.[3] Yet, little has been expended to develop effective control measures for this plant or to understand its life history. (Additional observation with respect to the effect of pollution on recreation is included in the section, Recreation).

Additional studies also are needed on the control of other groups of Lake Erie algae, particularly the blue-green species. This latter group imparts an unpleasant odor and taste to the water.[4] Such research is vital since an ever-increasing number of people are depending on Lake Erie for their domestic water supply. However, the channeling of research funds to single cures should be avoided. For example, the lake's algae problem has been attributed to an increase in phosphates, an inorganic substance that is essential to the development of most plants. It has been reasoned by some that if the control of phosphates entering the lake can be achieved, the

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[1] Boating 1967, National Association of Engine and Boat Manufacturers, New York, 1968.

[2] Water-Oriented Outdoor Recreation in the Lake Erie Basin, U.S. Bureau of Outdoor Recreation, Ann Arbor, Michigan, 1966.

[3] Water-Oriented Outdoor Recreation in the Lake Ontario Basin, U.S. Bureau of Outdoor Recreation, Ann Arbor, Michigan, 1967.

[4] Palmer, C. Mervin, Algae in Water Supplies, U.S. Department of Health, Education, and Welfare, Washington, D. C., 1962.

control of algae growth can similarly be achieved.[1] Yet, it has been demonstrated that phosphates may not be the sole controlling factor.[2] Therefore, in the search for an answer to the problem, other solutions must not be ignored.

It needs to be emphasized that Lake Erie should not be abandoned as a lost resource. Through research and cooperation, we should be able to slow the eutrophication or "aging" of the lake and make more effective use of this resource.

Hennigan states the program required for effective water quality management in the Great Lakes includes the following elements:[3]

- Basin-wide planning and regulatory coordination to insure a comprehensive, unified approach to regional water use and needs.
- Planning, construction, and operation of necessary drainage and sewage collection and treatment facilities and industrial waste treatment facilities.
- Effective control measures to eliminate or reduce input of heat, oil, sediment, pesticides, nutrients, dissolved salts, boat discharges, and solid waste.
- Fixed responsibility for clean-up and disposal of weeds, algae, oil, sludge deposits, dead fish, and other deleterious matter.
- Research programs to advance knowledge of pollutants, to improve collection and treatment methods, to better understand water movement, to improve the fishery, to develop organization and financial arrangements to more effectively meet goals.
- Graduate, undergraduate, technician, and in-service training to provide the needed manpower.
- A comprehensive, continuously operating surveillance program to show long-term trends, to pin-point problems, to evaluate activity, to help plan future action.
- Impoundments and stream flow regulation on tributary streams to eliminate nuisance conditions, to equalize waste-water dilution, and to maintain acceptable environmental conditions.

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1 Tarzwell, Clarence M., Conference in the Matter of Pollution of Lake Erie and Its Tributaries, Cleveland, Ohio; U.S. Dept. of HEW, Washington, D. C., 1966.

2 Mackenthun, Kenneth M. and Ingram, William M., Algal Growth Aqueous Factors Other Than Nitrogen and Phosphorus, Federal Water Pollution Control Administration, Washington, D.C., 1966.

3 Hennigan, *op. cit.*.

- A public education program to develop support for effective action and to counter misinformation about the water resource and water quality management.

Hennigan also lists some of the significant problems and conflicts which must be overcome to accomplish the water quality management objectives described above:[1]

- Cost of needed facilities coupled with competition for tax monies, and constraints on local government financing.
- Failure to delineate Federal, state, and local program responsibility and to provide a needed focus.
- Varying state programs, both in concept and execution.
- Multiplicity of local governments in metropolitan areas; lack of area-wide approaches to water, sewer, and drainage needs; combined sewer systems and old mills and subsequent problems; and poor operation of existing municipal and industrial treatment facilities.
- Reluctance of industry to take action, the buying of time by obfuscation, and playing off levels of government and experts, one against the other.
- The lack of knowledge and need for research, particularly on ecology, nutrients, pesticide, heat, storm water control, advanced waste treatment, and institutional arrangements.
- Professional disagreement on effluent and receiving water standards, treatment and removals required, and underlying philosophy of water quality management.

For the purpose of this study, the problems in water quality and control which are of greatest concern to Lake Erie and Lake Superior have been arranged into the following categories: (1) measurements of pollution and its effects, (2) eutrophication and algal growth, (3) pollution control and waste management, and (4) institutional implications. A brief review of the measures which have been recommended for water quality control by the major concerned agencies in the Great Lakes Region and the National Planning Association are included.

Measurement of pollution and effects.--The measurement of pollution and its

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[1] Ibid..

effects is a major component of the management and control effort to conquer the water pollution problem, particularly in Lake Erie. Three general categories of information are required in order to evaluate the effects of waste discharges in the lakes or any of their tributaries or connecting channels:[1]

- The nature of the waste material itself.
- The movement of the waste material within, or along, the coastal zone waters.
- The way in which the waste material interacts chemically and biologically with the lake environment.

Information with respect to the eight general categories of water pollution substances is collected largely on the basis of three classifications: bio-degradable materials; toxic substances (including other conditions such as temperature); and suspended solids. Bio-degradable materials consist of complex organic compounds which break down through biological action in the aquatic environment into their simpler component nutrient materials. While these materials may not be directly toxic to aquatic life, they can indirectly damage the aquatic environment. For example, excess algal growth and consequent oxygen deficiency in the lake waters can cause damages of this kind. Toxic materials may poison aquatic life directly, or cause abnormalities in eggs or larvae. Suspended solids may harm the aquatic environment by either being deposited on the bottom or while in suspension interferring with light penetration.

The second important kind of information needed to evaluate pollution in the coastal zone waters involves a measurement of the movement of waste materials after being discharged into the water. Variations in volume, concentration, or composition of waste discharges will have different degrees of impact depending upon the

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1 Wastler, T.A., "Instrumentation Requirements for Pollution in Estuaries", a paper presented to the Marine Technology Society, Washington, D.C., February 29, 1968 (unpublished).

movement of the water into which it is discharged. For example, even small variations of discharge in an estuary or nearshore area with little current movement will have significant impact due to concentration build-up. These areas will require more careful monitoring and control, or even artificial stimulation of water flows. Discharges into tributaries or connecting channels are more rapidly carried away and dispersed or diluted. Thus, levels of river flows are an important factor in maintaining dispersion or diluting these waste materials. Other variables or modifying factors which affect the movement of water and waste dispersion are stratification (common in estuaries), tides, river discharges, local currents, and bottom and shoreline topography.

Information to determine the interaction of components of waste discharges with the biological and chemical peculiarities of the coastal water environment is the third important problem of evaluating water pollution in the coastal zone. Information concerning the chemistry and biology of fresh water rivers and lakes is much more exacting than from the ocean. For example, total dissolved solids content in Great Lakes studies are measured in parts per million, as opposed to measurements of three orders of magnitude higher in the ocean environment.

Monitoring systems in Lake Erie and Lake Superior should be located to cover all possible variable conditions: (1) near the sources of out-fall and adjusted to the particular waste discharge; (2) frequent enough to permit recognition of concentration build-ups due to increase in discharge rate or occurrences of decreased flows or stagnation in water circulation; and (3) at varying depths and locations according to stream flow of lake circulation patterns to determine areas of pollution concentration and areas relatively free from severe pollution conditions. Overall measurements basic to evaluting the effects of water pollution, particularly in nearshore waters, include: temperature, salinity, dissolved oxygen, turbidity, current speed, and current direction. Depending on the nature of the wastes being discharged, other special measurements may be necessary, such as for bio-degradable materials -- including BOD (Biochemical Oxygen Demand) and total organic carbon -- as well as for high inputs of inorganic nutrients (such as nitrates and phosphates) including chlorophyll concentration.

The need for a more effective environmental monitoring system throughout the/ Great Lakes is widely expressed throughout the scientific and engineering community. In terms relative to the need for environmenta data in Lake Superior to monitor the local and lakewide impact of "waste discharges" such as the taconite tailings at Taconite Harbor or the thermal effluent from the power plant at Marquette on still essentially pristine waters, and to the measuring of pollution concentrations in Lake Erie to guide abatement programs -- the pollution monitoring program of the FWPCA should be broadened and strengthened to include the above parameters. Additionally, it would be of benefit for the FWPCA to further cooperate with academic and other research institutions, agencies, and industry in providing technical assistance and the use of lake monitoring stations in the conduct of related research activities.

The design and use of remote sampling equipment and automatic instrumentation of a high degree of accuracy for obtaining the information (necessary to evaluate the effects of pollution) would be a significant help to developing a monitoring system for Lake Erie.[1] The design of such equipment for the coastal zone of Lake Erie and Lake Superior would have certain unique requirements in relation to similar gear designed for the ocean environment. Advantageous design features to be incorporated in automatic instrumentation in the coastal zone would include: provision for easy and frequent servicing; ready accessibility to shore power supplies; suit-

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1 From discussion of a meeting of the Federal Interagency Committee on Great Lakes Research, Detroit, Michigan, July 23, 1968.

ability for use in shallow waters, and exposure to highly variable and rapidly changing conditions of winds, waves, and currents and close and frequent passage of large and small vessels; and capability of measuring large and rapid variations in parameters, (but not to the extent required in ocean measurements). The variety of nearshore "micro-environments" is much greater than that encountered in the ocean environment. Another characteristic of pollution measurement to be considered in automatic instrumentation design is that some parameters are not now subject to measurement with automatic sensing techniques. Therefore, devices are needed to collect and store stamples for later measurement or analysis, rather than making in situ measurement or analysis. Wastler describes four specific types of instrumentation that would be useful for monitoring pollution in nearshore or estuarine environments:[1] (1) current-measuring devices, (2) automatic warning devices, (3) biological sampling or sensing devices, and (4) devices to collect and store water samples.

The main problems associated with measurement of pollution and its effects in the coastal zone of Lakes Erie and Superior may be summarized as follows:

- Identification and measurements of different kinds of water, air, and land pollutants in the coastal zone as a function of distance from the shoreline. (Land pollutants include solid waste disposal, derelict buildings, litter, and weeds).
- Shifts in pollutant concentrations, including chemical interaction of pollutants; seasonal variations or climatic effects; and detection of other shifts in concentration and causal origins.
- Effects of pollution on oxygen deficiencies of water.
- Effects of pollution on ecology of aquatic plant and animal life.
- Effects of water and air pollution on the ecology of terrestrial plant and wildlife.

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1 Wastler, op. cit..

- Effect of water pollution on humans, including denial or diminished use for water-oriented recreation; harmful biological effects on humans; deteriorating effects of pollution on taste of drinking water or fishery products; desirable or undesirable effects of thermal pollution; harmful aesthetic effects; and other costs of water pollution (i.e., increased expenditures for boat maintenance, etc.).

- Effect of air pollution on human uses in the coastal zone, including harmful biological effects; negative aesthetic effects (esp., residential, tourist, and recreational effects); and other costs of air pollution (increased expenditures for laundry, clothing, paint, etc.).

- Effects of land pollution on human use of coastal zone, including residential, recreational, or tourist uses(especially negative aesthetic effects).

Eutrophication and algal growth.--As mentioned above, municipal and agricultural drainage, however well treated, unavoidably adds large quantities of nutrient materials to the water, producing growths of algae often of nuisance proportions. In terms of the process of eutrophication, Lake Superior is basically pristine, Lake Michigan is in the early stages, Lake Erie is in an advanced stage, and Lake Huron needs to be evaluated. The greatest research need is for information about the key mechanisms in the eutrophication process. For example, although nitrogen and phosphorus are known to be major contributors to the enrichment process, little is known of the role of organic micro-nutrients, including some not yet identified. Most studies to date have been largely descriptive, and have not delved adequately into the key areas of cell biochemistry, nutrition, and growth of algae. Additionally, research is needed for exploring ways to beneficially utilize the products of eutrophication, such as a fertilizer enrichment to achieve greater growth of fishery stocks, which may involve either developing strains of algae that fish will eat or developing a species of fish or zooplankton that will consume algae now present in the lakes. R&D is also needed to control algae pollution problems, such as that resulting from excess algae fouling a beach or clogging filters of a municipal water plant.

The following represents the major research categories under investigation and needed in the process of eutrophication and the interrelationship of eutrophication process with other resources and activities in Lakes Erie and Superior:

- Factors influencing eutrophication; depth of water nearshore (bottom slope); algal growth rates (see below); climatic changes; nutrients (kinds and levels); organic micro-nutrients; and cell biochemistry.

- Factors influencing algal growth rates, including identification and measurement of variables which determine growth rates; and interaction of variables and measuring effects of algal growth rates.

- Effects of algal growth on: seasonal oxygen deficiencies in water; lake ecologies; fisheries; recreational uses; and water quality for domestic and industrial uses.

- Control technologies (present or potential), including physical removal of algae and its disposal as waste; commercial utilization of harvested algae; use of chemical herbicides to control algae; reduction of pollutant nutrients (see below); land fills to increase depth of water nearshore; removal of bottom sediments containing decomposed algae and nutrients; hydraulic flushing; and biological control.

Pollution control and waste management by sources.--As mentioned earlier, the core of the water pollution problem lies in the consequences of using river systems to carry off raw or insufficiently treated sewage (resulting from inadequate secondary treatment facilities) and using the lakes as a receptacle. The problem is being compounded by the increase of waste discharges to overloaded proportions due to the increase in population and urban and industrial growth, and with the latter, the introduction of new toxic agents and waste materials that are even more lethal to the aquatic ecology.

The problem of developing control standards and methods is made difficult by the variety of pollution agents. These problems fall into three broad areas. First, wastes are mixtures of the general categories of pollutants mentioned above. This condition complicates the design and operation of treatment and control systems. Municipal wastes usually contain oxygen-comsuming wastes, synthetic organic chemicals, and sediments. The same is true of many industrial wastes which may contain substantial amounts of heat from processes other than cooling. Land drainage usually contains substantial organic matter in addition to sediments, as well as lesser amounts of radioactive substances and air pollutants washed from the sky, vegetation, buildings, and streets during rainfall.[1]

Secondly, the matter of adequate flows of water in tributaries and connecting channels of the lakes is another large factor in pollution control. Although it is important that secondary (and even tertiary) treatment of wastes be accomplished

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[1]Lea, Sperry, "Fresh Water in a Canadian American Context," a draft study prepared for the Canadian-American Committee of the National Planning Association, September 1965.

before they are discharged into water bodies, stream flows must be mentioned.[1] If emission loads are to be increased, it would be desirable (provided this is economically feasible) to increase stream flows for dilution purposes.[2] In part, this is because so much insufficiently treated waste is still being discharged into streams and, in part, because existing treatment technology cannot yet handle economically some of the newer chemical pollutants. Thus, there is a crucial link between quality and quantity of fresh water, especially in industrial areas.

Thirdly, the problem of waste interaction further complicates the pollution situation. Once discharged into the diluting water body, some of the new polluting agents may interact with each other or with normal aquatic life to trigger the generation of yet more pollution, as in Lake Erie.[3]

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[1]Additionally, a scale model of Lake Superior is being used by the University of Wisconsin to study the patterns of the lake's currents in an effort to solve some of the problems of water pollution and conservation. Parks and Recreation, July 1968, p. 59.

[2]Several schemes have been proposed, and in some cases implemented, for increasing stream flows and providing increased amounts of fresh water flows to shoreline areas to dilute pollution concentration. These include the deepening and widening of connecting channels between lakes, described further in the later section of Water Resources Management (Sperry Lea) the pumping of fresh water from offshore to nearshore areas and beaches for release (Harold Goodwin), and the pumping of fresh lake water to tributary rivers for release upstream from urban concentrations and/or the construction of holding reservoirs to release water during peak pollution loading periods or natural low flow levels (Miller Spangler).

[3]Here the dissolved oxygen content of the water is lowered by the influx of untreated organic wastes. Meanwhile, plant nutrients, some derived from synthetic organic oxotics--especially detergents--stimulate the runaway growth of algae. Besides being a nuisance to beaches and to water treatment equipment, the algae eventually sinks to rot at the lake bottom, becoming itself an oxygen demanding waste. As the dissolved oxygen becomes depleted at the lower levels, dying fish degrade the recreational and commercial value of the lake, and create still further demands for oxygen. (Lea, op. cit.).

Pesticide buildups are threatening to contaminate the coho salmon fishery in Lakes Michigan and Superior beyond levels considered safe for human consumption. Such contamination also poses a threat to the growing commercial and sport fishing industry dependent on the coho salmon. Reacting to the growing pressure for stricter enforcement, the Food and Drug Administration in March 1969 seized 28,000 pounds of frozen coho salmon in warehouses in Milwaukee, Superior and Duluth that were infected by pesticide residue.[1,2] The FDA had found composite readings of DDT as high as 19.5 parts per million (ppm.) in the salmon and lesser amounts of deildren.[3] This is nearly three times the level found in 1967 run fish. Levels in the fat of lake run fish, where the pesticide tends to concentrate, run as high as 50-60 ppm., according to Bureau of Commercial Fisheries studies.[4]

The complaint filed by the FDA in the Federal Court in Milwaukee stated these levels made the fish unsafe for consumption. While 7 ppm. (5 ppm. in fish) is considered an admissible level for consumption, the danger of DDT and other chlorinated hydro-carbons to humans and wildlife has not yet been clearly defined.

Much of the actions initiated against pesticide contamination was initiated by a suit made by a private conservation group called Environmental Defense Fund.[5] This organization has secured the assistance of scientific witnesses, including fishery and wildlife biologists, botanists, organic chemists, a pharmacologist, and an entomologist in trying to prevent local and state agencies from using DDT or

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[1] "The Environment: Beyond the Bug," Time, April 18, 1969, pp. 24-25.

[2] "Wisconsin Wildlife Officials Alarmed," The Washington Post, April 19, 1969, Washington, D. C., p. F-13.

[3] Ibid..

[4] "The Environment: Beyond the Bug," op. cit.

[5] "DDT: The Critics Attempt to Ban Its Use in Wisconsin", Science, Vol. 163, Feb.7, 1969, pp. 548-549.

dieldrin by filing precedent-setting legal suits in state and Federal courts in Michigan and Wisconsin. The EDF has also taken advantage of the Wisconsin Department of Natural Resources administrative hearing procedure. The Department is now in the process of conducting hearings to determine if DDT should be banned as a stream pollutant. In the face of "popular reaction" to pollution problems apparently emanating from the use of DDT, dieldrin, and other pesticides expressed through the petition of court orders to ban the use of these chemical agents, it was stated:[1]

> ...in general, judges have held that it is within the discretionary authority of state and local agencies to decide whether or not to use pesticides, and that for the courts to interfere would be improper.

However, in the case of Wisconsin, the Citizens Conservation Group (Environmental Defense Fund) has not had to test far-out legal concepts since a 1943 Wisconsin stature permits citizens to petition for a ruling on how, or whether, laws or regulations (in this instance, the water quality standards) which it administers apply to a particular question--in this event, the charge that DDT is a pollutant. The Department of Natural Resources' willingness to rule on the anti-DDT petition, presented by EDF on behalf of two Wisconsin conservation groups, is believed in itself to be significant; for had the Department wished, it no doubt could have found reason to reject the petition.[2]

Testimony at hearings at Madison, Wisconsin, on the petition to ban the use of DDT also indicated diverse opinions.[3] One testimony, for instance, indicated DDT poses on threat to human health and that the Lake Michigan coho salmon seized by the FDA because of high DDT levels would have been safe to eat.

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[1] Ibid..

[2] Ibid..

[3] Air and Water News, May 5, 1969, p.6

DDT residue in the fish ranged from 13-19 ppm.;and the FDA established a guideline of 5ppm. for fish after the seizure, which would tend to indicate a lack of clear-cut data upon which to set such standards. For instance, a study was reported of workers in a DDT plant who were exposed for as long as 19 years to doses estimated at 14-42 mg./day (as compared to the average dose of .028 mg./day per man). They showed no ill effects because the human body eventually builds up a balance point at which it excretes DDT. On the other hand, another study was quoted which showed the liver tissue of persons who died of liver diseases contained 2 to 2.5 times as much DDT as the tissues of persons who died of natural causes.

Indeed, the good and bad effects of pesticide use is a controversial issue. In a recent public statement, one authority condemned the use of DDT, while another presented views in support of its use. In condemning the use of DDT, it is said that the root of this problem lies with the DDT molecule itself, for it combines four properties that are responsible for its behavior in the environment:[1]

(1) Toxicity to almost all animal life rather than simply the insect pest.

(2) Persistence, so that it remains in its original toxic form for at least a decade and perhaps much longer.

(3) Mobility, so that it doesn't remain where applied, but is carried about the earth by currents of water and air.

(4) Solubility properties that cause it to be accumulated by living organisms, instead of getting 'lost' in the oceans, in soils or in other inorganic parts of the environment.

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[1] Wurster, Charles F., "It's Polluting All the World", part of a dual article on "DDT: Boon to Man--or Ban to Our Environment", The Washington Post, May 4, 1969, Washington, D. C., pp. B-1, B-3.

On the other hand, those who endorse the use of DDT claim:[1]

> First, DDT is safe, and has been studied more than any other pesticide for its effects on human beings. Without pesticides, there wouldn't be enough food to go around. Next, the campaign against DDT is emotional and unscientific, and I object to this. Most important of all, DDT is needed by the millions of 'Third World' people because it is a cheap, safe residual pesticide.

In the face of such contrasting views, the buildup of pesticides in coho salmon caught in Lake Michigan and its tributaries has led the Michigan Agriculture Commission to temporarily ban the sale of DDT in Michigan.[2]

The Michigan Agriculture Department in early April 1969 voted to cancel registration of the pesticide, DDT, effective in 30 days. The action would totally ban sale, manufacture, or use of the pesticide in the state, although use of them already is nearly phased out.[3]

However, the Michigan Attorney General stated that the DDT ban cannot go into effect until mid-June after the spring planting season because state law requires a 30-60 day grace period to allow distributors to get rid of there supplies and manufactureres to adjust their marketing programs. There are also provisions for anyone affected by the ban to request a hearing.[4]

In the case of Lake Michigan, DDT and its by-products have been indicted by experts of Michigan State University's Fisheries and Wildlife Department as threatening the lake's burgeoning new industries of sport and commercial fishing for the

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[1] Jukes, Thomas H., "Its Use Saves Untold Lives", part of a dual article on "DDT: Boon to Man - or Ban to Our Environment", The Washington Post, May 4, 1969, Washington, D. C., pp. B-1, B-3.

[2] "Michigan Outlaws DDT," The Washington Post, April 17, 1969, p. A-4.

[3] Air & Water News, April 21, 1969, p. 2.

[4] Ibid..

coho salmon.[1] DDT was blamed for results of recently completed hatchery studies which showed that about 11% of the first year's eggs that were hatched from Lake Michigan experienced fatal seizures; and in some batches of fresh eggs, up to 73% of the fish died.

Others have reported harmful effects to wildlife via subtle metabolic changes which only recently have been detected. Testifying before a Wisconsin Department of Natural Resources hearing considering the banning of DDT, a biologist for the U.S. Department of Interior's fish-pesticide laboratory said that offspring of trout which had been fed small doses of DDT showed higher mortality rates and more stress from environmental conditions.[2]

In addition to the temporary ban of DDT, The Governor of Michigan also announced the following steps:[3]

- Arranging with Wisconsin Governor Knowles to set up a five-state governors' conference to plan action;
- Ordering of an immediate pesticide monitoring program by the Water Resources Commission;
- Establishment of a Bureau of Water Management with the Department of Natural Resources; and
- Establishment of a cabinet-level Council for Environment Quality.

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[1] Air & Water News, March 17, 1969, p. 3.

[2] Ibid..

[3] Air & Water News, April 21, 1969, p. 2.

In April, the five states surrounding Lake Michigan announced formation of four committees to prepare data for the FDA:[1]

- A committee of water pollution control experts to set up a monitoring system on the lake;
- A panel of public health experts to review information relevant to the health hazards of pesticides;
- A committee of agricultural experts to evaluate the impact on agriculture of pesticides;
- A committee of state natural resource and recreation experts to evaluate ecological effects of existing pesticide levels and their continued use, and to determine the economics of fishing income loss.

The Governors also petitioned the Federal Government not to permit the FDA to set tolerance levels of DDT until the states have a chance to submit their own data.

The Secretary of HEW has appointed a special Commission on Pesticides and Their Relationship to Environmental Health to look into the effects of pesticides on the environment and will place special emphasis on DDT. The Commission is to make its report with specific recommendations in six months. The FDA has in the meantime placed a 5 ppm. interim limit on the amount of DDT in fish shipped through interstate commerce, but which could be changed after the commission makes its report.[2]

According to Dr. Robert Sweeney, one of the problems of pesticide buildups in fish and wildlife is that the nationwide monitoring system established under the FWPCA in cooperation with state agencies is primarily aimed at water sampling for chlorinated hydro-carbons on a river basin basis and does not adequately include continuous monitoring of organisms living in the water.[3]

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[1] Air and Water News, April 28, 1969, p. 2

[2] Ibid.

[3] By personal communication

Concentrations of pesticides may vary to a greater or lesser extent in organisms, such as algae, larva, or fish, within a given concentration in a water body. Adequate sampling has not been done to test the pesticide concentration in Lake Erie or Lake Superior. A pesticide sampling program on Lake Erie in 1964 and 1965 failed when the samples were contaminated accidentally in transshipment to the laboratory. Monitoring stations under the FWPCA nationwide system have been set up at sites on the Detroit and St. Clair Rivers, Milwaukee on Lake Michigan, Duluth on Lake Superior, Maumee River at Toledo, and Buffalo on Lake Erie. Consideration should be given to expanding the scope of the monitoring system and strengthening the cooperation between the FWPCA, the Department of HEW, and the Department of Agriculture in determining consumption tolerances and management practices in the use of pesticides to enable the beneficial use of pesticides in agricultural production and at the same time not be harmful to public health as well as fish and wildlife. Cooperation in providing monitoring and other technical assistance by these Federal agencies to state and local jurisdictions should be strengthened.

It is also frequently argued that the burden of responsibility to demonstrate safe tolerance levels in the use of pesticides should fall on the industrial producers of the materials--as is the case in drug manufacture--or the agricultural agencies that regulate direct use. However, it should be pointed out that the extremely wide and complex range of indirect social and economic costs and benefits, and various kinds and degrees of ecological impacts may be beyond the capability of much of the manufacturing industry or regulatory agencies to assess. In fact, to place this assessment responsibility completely on these organizations may effectively discourage the manufacture and use of DDT because of the high costs and risk involved. While not attempting to anticipate the outcome of the present scientific and legal controversy over the use of such pesticides in the Great Lakes Region, it is suggested that a broader institutional base is needed to support R & D into the continued use of pesticides; and in which case, the Marine Sciences Council should take initiative in identifying its stake in evaluating the impact of pesticide use in the coastal zone environment, especially marine species of animal and plant life.

Another important pollution control problem is that, for many cities, storm sewers are combined with sanitary sewers. The Water Quality Act of 1965 established a four-year program of R & D grants to demonstrate new or improved methods to eradicate the combined sewer problem. For this purpose, Congress voted an annual appropriation of $20 million for fiscal years 1966-69. The FWPCA reports the results of these studies will be available soon. Lake Erie Report states that it will cost roughly $3 billion to separate or to convert combined sewerage systems (where feasible in redevelopment) to accommodate the 40 billion gallons per year sewage that flows into the basin's waterways.[1] About one half of this flow is the result of storm-surge overflows, primarily from Detroit, Cleveland, and Toledo.

An alternative to the separation of combined storm and sanitary sewer systems into dual or separate systems is to utilize various kinds of reservoirs to hold the overflow of sewerage during storms in order to then treat it at off-peak periods. The FWPCA is experimenting with developing a holding system with collapsible synthetic rubber bags at Sandusky, Ohio.[2] The FWPCA has also sponsored a study of the feasibility of constructing a holding pond on the edge of Lake Erie just easterly

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[1] Lake Erie Report: A Plan for Water Pollution Control, Federal Water Pollution Control Administration, Great Lakes Region, Washington, D. C., August 1968, p. 57.

[2] "Underwater Storage of Storm Overflow", Environmental Science & Technology, Vol. 2, No. 9, September 1968, p. 668.

of Cleveland.[1] The Chicagoland Deep Tunnel Project proposes to develop an underground sewerage storage reservoir 800 feet below the surface utilizing breakthroughs in tunneling methods.[2] The proposal may also provide useful side benefits and cost savings by providing a source of quarry materials.

It is estimated that the construction of a 900-acre shoreline holding reservoir easterly of Cleveland capable of holding 30,000-acre feet (almost 10 billion gallons) would cost approximately $72.6 million, including $52.6 million for the reservoir, $11.7 million for the collector system, and $8.3 million for the pumping station.[3] The 10 billion gallon holding reservoir has the capacity to hold about one half of the storm surge overflow running into Lake Erie and, in which case, serves as a reasonable size to make crude cost comparisons for alternative reservoir facilities. The proposed basin would treat flows from a number of large combined sewer overflows from several polluted streams and effluent from a large secondary waste-water treatment plant. Treatment would consist of bio-oxidation, sedimentation, stabilization, and disinfection. A shoreline collection system would be included to convey flows to the basin. Estimates of costs of the basin and collection system were prepared, and it was concluded that the stabilization basin would provide a higher degree of pollution abatement than would separation of sanitary and storm sewers at about one third the cost.[4]

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1 (Consulting Engineers), Feasibility of a Stabilization Retention Basin in Lake Erie at Cleveland, Ohio, Havens and Emerson, Cleveland, Ohio, May 1968.

2 Koelzer, Victor A.; Bauer, William J.; and Dalton, Frank E., "The Chicagoland Deep Tunnel Project — A Use of the Underground Storage Resource", A paper presented at the 41st Annual Conference of the Water Pollution Control Federation, op. cit..

3 (Consulting Engineers), op. cit..

4 Simpson, George D., "Treatment of Combined Sewer Overflows and Surface Waters at Cleveland Ohio", A paper presented at the 41st Annual Conference of the Water Pollution Control Federation, op. cit..

The cost of submerged rubber bags to hold 10 billion gallons with present technology would run in approximately $200-300 million.[1] The advantage of using underground storage reservoirs, bags, or offshore diked ponds is that they can be located flexibly along the shoreline in a manner convenient to natural tributaries or drainage outflows or can be linked by a collector piping systems without competing for expensive land space. The important problem is, however, that insufficient engineering data exists to determine the feasibility of these alternative approaches to, or combinations to go with, separation of storm and sanitary sewer systems. While the FWPCA is conducting R&D into these areas, this work should be strengthened in order to provide better data to include in decisions committing to long-scale public works, such as Cleveland's $100 million sewerage bond program, part of which is to be spent in separating sewers.

The City of Buffalo, in cooperation with the FWPCA, has begun installation of an experimental air barrier across the Buffalo River as part of $737,000 attempt to find ways to prevent oil pollution of the river. Three plastic pipelines forming the barrier will be laid diagonally across the bottom of the river at the Michigan Avenue bridge. It is hoped that the stream of compressed air emitted will produce opposing currents that will impound the oil and permit it to be collected. Various methods will be tested for skimming the collected oil from the river's surface. Under a research contract with the city, Cornell Aeronautical Laboratory designed the air barrier system which will permit passage of ships -- a process impossible in a system utilizing floating booms.[2] The pipelines may also be strung around a

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1 "Underwater Storage Storm Overflow", Environmental Science & Technology, op. cit.. FWPCA in April 1969 reported the figure stated in the article of $15,000 for inflatable 100,000 gallon capacity synthetic bags is more in the range of $20-30,000.

2 Air & Water News, May 12, 1969, pp. 1-2.

waterfront perimeter to keep pollution out of a beach area.[1] Similar techniques have been used to fence out alewife in central programs in Lake Michigan[2], which would suggest that the possible effects on fish life be considered in the use of air bubble pollution control systems.

R&D efforts also include development of a monitoring device that can be installed in sewers to detect and measure quantities of oil and a print method of identifying oil to determine its source by its base.[3]

The Department of Interior and the Coast Guard have also reached agreement in most areas on which agency has control over oil spills and cleanup.[4] The agreement includes the following:

- The basic fixing of responsibility in a cleanup should be by the President, with authority delegated to various agencies.
- Where there is a discharge from a vessel or onshore or offshore installation, either agency should be contacted immediately with that agency notifying the other. (Right now, the discharger must notify the Secretary of Interior, but the department recognizes that the Coast Guard has more of an interest in vessels.)
- The Department of Interior in consultation with the Department of Transportation should issue regulations on water quality and cleanup procedures, including use of detergents and dispersants.
- The Coast Guard should have the basic authority to issue regulations on physical methods of cleanup in conforming with Interior cleanup regulations.
- The Coast Guard should issue regulations on prevention of oil discharge from vessels.

These regulations should also spell out the responsibilities and authorities of states within whose jurisdictions such oil spill emergencies occur.

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1 Air & Water News, February 17, 1969, p. 7.

2 Kupfer, George A.; and Gordon, William G., "An Evaluation of the Air Bubble as a Barrier to Alewives", Commercial Fisheries Review, September 1966, p. 9.

3 Air & Water News, op. cit..

4 Air & Water News, March 17, 1969, p. 4.

The Atomic Energy Commission claims no authority over regulating thermal discharge from nuclear power plants, either under its licensing regulations or under the executive order that calls on all governmental agencies to provide leadership in cutting water pollution.[1] Current congressional hearings into this problem have found that little real effort has been made to control waste heat discharge from nuclear plants, and there is almost no specific information available to determine the ecological effects of large-volume hot water discharge from a nuclear facility. With the increasing power requirements of the regions neighboring the shores of Lake Erie -- and to a lesser extent, Lake Superior -- and the increasing need for nuclear and convention thermal power plants, it is imperative that such regulatory authority be crystalized and data on environmental impact of heat effluents be developed. The use of thermal effluents along the Lake Erie and Lake Superior shorelines have both great opportunity for multiple use, such as with recreation areas (as is discussed later), as well as potential for rendering harmful environmental effects if discharges are not properly controlled. The Marine Sciences Council could take a first step by reviewing the permit application for power plants submitted to the AEC and be the lead agency in coordinating inquiry into multipurpose and environmental impact in the coastal zone. From this role, further recommendations could be formulated by the Marine Sciences Council to establish a continuing functional review procedure for this purpose and ways and means for accomplishing multipurpose objectives in power site location and construction projects.

Review of pollution control measures.--Considerable study has been given to the study of water quality in the Great Lakes, and an extensive number of recommendations have been formulated for remedial actions for the problem of pollution and

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1 "Atomic Power Plant in Hot Water", Business Week, June 29, 1968, pp. 69-72.

accelerated aging of Lake Erie. Many of these measures have involved or have grown out of remedial actions that have already been initiated; others reflect new approaches which would meet pollution control needs or objectives if the appropriate technology were developed or innovations applied to increase efficiency or lower costs of existing approaches to the pollution problem.

Measures which have been recommended for preventative and restorative measures presented in four major reports on this subject have been complied in summary form and, together with additional measures and commentary by NPA, are included as Appendix A.[1] The four major reports reviewed were:

- Lake Erie Report: A Plan for Water Pollution Control, Federal Water Pollution Control Administration, Great Lakes Region, Washington, D.C.,August 196
- Great Lakes Restoration -- Review of Potentials and Recommendations for Implementation, Pacific Northwest Laboratories, Battelle Memorial Institute, Richmond, Washington, June 17, 1968.
- Great Lakes Basin Comprehensive Framework Study, Plan of Study Document, (Tentative Unpublished Draft), Great Lakes Basin Commission, Ann Arbor, Michigan, September 1968.
- Early Action Program, Volume III, "Public Facilities and Services for Economic Development, Lake Renewal and Management", Upper Great Lakes Regional Commission, Washington, D.C., March 1968.

These studies were selected because of their concern with water pollution problems in the Great lakes Region. They deal both with local and lakewide pollution problems and with comprehensive and specific aspects of pollution control measures. In addition to the Lake Erie Report, the other reports provided information and measures that can be directly interpreted for application to Lake Erie and Lake Superior. Recommendations and accomplishments of state and local governments surrounding the two lakes have been made which, while local in their concentration,

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1 Because of the space required to accommodate a large number (over 200) of meassures compiled and a commentary, these were placed in the Appendix.

may have impact on an extended part of the lake and, consequently, should be considered an integral part of developing regionwide water pollution control and abatement programs.

The measures for water pollution control have been divided into two major categories: preventative and restorative. Preventative measures are employed to remove nutrients before discharge into the lake or tributary and are oriented toward removing the causes of pollution and accelerated eutrophication. Restorative measures are used to remove the nutrients or the products of eutrophy from the lake. Because the problem of pollution in its broadest sense involves the prevention of the cause of pollution and the restoration of resources that have been degradated from the pollution, both of these aspects should be included in an overall approach to the problem. Furthermore, it is the combined approach of pollution prevention and restoration that needs to be analyzed with respect to identifying the potential benefits which may be provided other uses of the coastal zone such as shoreline development, transportation, and urban development.

The recommendations of Appendix A are treated under the following headings:

I. Preventative Measures

(1) Recommendations for nutrient-removal measures.

(2) Recommendations for R&D for nutrient-removal measures.

(3) Recommendations for non-nutrient pollution abatement measures.

(4) Recommendations for R&D on non-nutrient pollution abatement measures.

(5) Recommendations for R&D for both nutrient and non-nutrient pollution abatement measures.

(6) Recommendations on pollution abatement standards.

(7) Recommendations for R&D in setting and controlling standards for pollution abatement.

II. Restorative Measures

(8) Recommendations for restoration measures.

(9) Recommendations for R&D in the restoration of Lake Erie.

While the FWPCA Lake Erie Report stated that the technology needed to solve the pollution problem in Lake Erie was largely in hand, virtually all of the preventative and restorative measures recommended would benefit in varying degrees from additional R&D. Further R&D in present pollution technologies, for instance, can lead to innovative developments which would increase the efficiency or lower the cost of pollution-control methods and which may consequently change (in some cases, possibly radically) the cost/effectiveness framework within which decisions are presently being recommended and made committing to large-scale, expensive public works projects, such as the City of Cleveland's $60 million bond issue for separate sewer facilities. For instance, would other cities follow this same approach if new, cheaper (including the cost of R&D) technology were developed for constructing holding reservoirs for storm drainage surges in order to utilize the cost efficiency of a joint (or shared) sanitary and storm-sewer gathering system, and also thus enabling secondary treatment of urban runoff waters? Additionally, R&D to develop a wide variety of effective sewage treatment and waste disposal technologies will increase the potential of establishing compatibility of a greater number of land and water uses in the coastal zone which now have incompatible characteristics because of the effects of their by-products.

The R&D measures listed in the summary recommendations of Appendix A are those which were specifically identified in the reports deserving of emphasis for implementing measures for immediate action. The main criteria by which the recommendations are ranked are the urgency and contribution to the problem criteria referred to earlier. In this regard, the Great Lakes Restoration Report cites the following ranking of causes of accelerated aging of Lake Erie based upon the combination (individually or in combination) of the pollutants to the process of the eutrophication:

High Impact

Municipal Wastewater
Agricultural Runoff
Sediment Interchange

Medium Impact

Industrial Wastewater
Combined Storm Sewage
Urban Land Drainage
Dredging
Tributary In-Flow
Fisheries Considerations

Low Impact

Water Craft Waste
Oil and Discharges
Waterfowl
Sub-Surface Disposal
Atmospheric Quality Deterioration

In the selection of measures based upon priorities from among the extensive lis of (ranked) alternative measures, the source reports present some observations, conclusions, and assumptions which may have influence over the application of criteria and strategies for action. As examples, some of these are discussed below and are by no means all-inclusive, either in terms of the many other implications that can be derived from further careful analysis of the source reports or from analysis of other related Great Lakes studies and on-going research operations.

Several assumptions about public awareness and commitment to solving the pollution problem have been made in the analysis of various restoration measures which should be considered as useful guides to the choice of strategy to pursue a restoration program for Lake Erie. The assumptions are as follows:[1]

[1] Great Lakes Restoration Report, op. cit., p. 5.

- Restoration is desirable because of the benefits which would accrue to society.
- Restoration is possible; for example, Lake Erie is not already "dead".
- The public desire is to maintain a quality environment both for today and as its legacy for the future.
- The public is willing to bear the cost of maintaining a quality environment. For example, if the assumptions hold true that the public is willing to bear the cost of maintaining the quality of environment through the restoration of Lake Erie, then the Federal Government has a clear mandate to proceed ahead with the initiation of a restoration program for Lake Frie. In this instance, confidence to the commitment to a long-range program buildup should be modified by the implication that "restoration measures must be implemented so that the time of lake reovery will be short enough to avoid substantial foregone benefits."[1] This statement was also made on the assumption that recommendations for preventative technology will be implemented. This assumption then would suggest a short-run strategy for the initiation of a Lake Erie Restoration Program in conjunction with preventative measures beings implemented pursuant to the Water Quality Act of 1965.

The present capability of solving the Lake Erie pollution problem is still subject to, and in need of, improvement. The Lake Erie Report states, "The tools are available for doing the job."[2] This includes the basic legislation, technical competence, and the equipment. While it is true that the five states[3] in the Lake Frie Basin have agreed to the requirements established by the pollution enforcements conferences and have submitted interstate water quality standards to the Secretary of the Interior (which set forth goals and ways to reach them), the cost-effectiveness relationships associated with carrying out these standards will change subject to the development of new technologies in pollution abatement devices, waste reclamation practices, level and availability of trained technicians to operate water

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1 Ibid., p. 45.

2 Lake Erie Report, op. cit., p. 67.

3 While Indiana is included within the geographical boundary of the Lake Erie Basin, it does not face directly on Lake Erie; and for this reason, it is not discussed in this study as a "coastal zone" state.

quality control systems, and scientists to develop better techniques. Obviously, the National Sea Grant Program will make an important contribution to the training of requisite technicians and scientists as well as to support certain applied research in enlarging the benefits of pollution control through restoration and other measures. The costs at which present pollution standards may be achieved are subject to possible reduction by the application of R&D. Furthermore, development of different and more efficient systems may require flexibility in commitment to present pollution abatement systems or anticipated restoration methods in order to implement the former. The prospects of technological advance in such systems would tend to suggest a hedge strategy in committing to programs based upon existing equipment and treatment systems.

The cost of sewerage and treatment facilities for the next five years sufficient to meet the requirements for municipal and industrial wastes is estimated to be approximately $4.5 billion, as shown in Table 1. The $4.5 billion price tag attached to a program to prevent further pollution to Lake Erie and restore the lake to established quality standards is, in large part, based upon application of existing technologies. For example, activated sludge techniques are primarily used in municipal wastewater treatment plants. Table 2 shows data compiled on various nutrient-removal treatment methods. The figures reflect a variety of ways to remove nutrients, some of which are more effective than the activated sludge method. However, the more effective methods are too expensive at this time to implement on a large scale. An important aspect of decisions committing to a given treatment process and the cost and effectiveness relationships associated with that decision is the inclusion of technological forecasting. Pivotal R&D may be applied for instance, to a technique to better determine the probability of a particular method to become available in the future. Such forecasting will influence the exte

TABLE 1

ESTIMATED TOTAL FIVE-YEAR COST FOR PREVENTION AND RESTORATION PROGRAM FOR LAKE ERIE (1969-1973)
(In Millions of Dollars)

Municipalities	
Treatment	$ 400
Sewer Construction	700
Industry	285
Lake-wide Sewer Separation	3,000
Lake Erie Restoration[1]	150
Total Program	$ 4,535

Source: Lake Erie Report, p. 9.
Great Lakes Restoration Report, p. 50.

[1] To provide a crude guideline for the order of magnitude of costs of a potentially feasible high-priority restoration method, the Great Lakes Restoration Report (pp. 45-51) provides an example of artificial re-circulation as a method for destratifying Lake Erie in order to reduce availability of nutrients from bottom sediments. It has been estimated that up to 40 million acre feet of bottom waters of the central Lake Erie Basin is subject to severe oxygen depletion during late summer stratification conditions. Artificial destratification of Lake Erie during these summer months (i.e., about 100 days) could be accomplished with the development and operation of a system of airlift circulators to displace about 40 million acre feet of bottom water by lifting it to the surface to be replaced with surface water circulating to the bottom. The engineering costs of such a system is estimated to be approximately $30 million annually. The cost of such a restoration program, therefore, would be $150 for the five-year period projected to accomplishment of the preventative program.

TABLE 2

EFFICIENCY OF NUTRIENT REMOVAL BY VARIOUS TREATMENT METHODS

Method	Total Netrogen Removal(%)	Total Phosphorous Removal (%)
Activated sludge	20 - 82	10 - 80
Algae removal systems	35 - 95	41 - 100
Chemical precipitation	12 - 68	78 - 100
Ion exchange	82 - 99.5	95 - 99.6
Membrane processes	50	50
Ammonia stripping	82 - 98 (NH_3)	-----
Effluent land spraying	54 - 68	76 - 93
Distillation	75	96

Source: E.J. Martin and L. W. Weinberger, "Eutrophication and Water Pollution", Proceedings Ninth Conference on Great Lakes Research, Publication no.15, Great Lakes Research Division, The University of Michigan, 1966.

of investment commitment to particular treatment methods and facilities; and in the event that cheaper and more efficient technology is anticipated, provisions may be made to accommodate such changes and proceed with the long-range development of a sewerage system.

To draw upon a hypothetical example, what would the likelihood be of the allocation of 10-20% of the $4.5 billion prevention and restoration program resulting in the development of new or better technologies to reduce the $4.5 billion figure within the five-year period? What would be the probability that $450 million spent on R&D for improved prevention and restoration systems would reduce the overall program costs by 30-50%? The element of probability of such forecasting can be better predicted if pivotal R&D is allocated to explore the possibilities to determine just what the outlook for such developments are before larger R&D commitments are made to achieve certain technology level or cost-reducing targets. This point is particularly applicable to the large cost of sewer separation, where -- for instance -- possibility exists to increase efficiencies of combined systems and, thereby, lessen the need for separation.

On the other hand, such R&D might be seized as an excuse to delay the implementation of already available technologies and so to postpone the social and economic benefits to be gained by an earlier improvement of the environmental quality, especially of Lake Erie. Thus, unless the R&D can be performed rather speedily (e.g., within a year or two), it would appear undesirable to postpone action programs for Lake Erie while awaiting the development of superior or lower cost technologies. This does not mean that all R&D should be halted on this behalf since growing population and industrial expansion will increase the needs for water pollution control measures and systems enlargements which could later take advantage of the improved technologies in certain coastal zone areas of Lake Erie, but especially in other great lake areas where immediate control measures are much less urgent.

Additionally, the principle of "multiple purpose" may be applied to R & D programs. Single-purpose R & D for prevention and restorative technology could provide other benefits by marginal increases in support to enhance spin-off value to other resources or functions within the coastal zone. For instance, research efforts to develop techniques to prevent pollution from dredge spoil disposal by depositing behind diked areas along the shoreline could be augmented to explore different shapes and possible situations in which such spoil banks could be used for a wider variety of useful purposes.

While some of these answers may be provided in sufficient detail through further research to commit at an early date specific short or long range programs, certain problems simply will not be solved and will need to be accommodated in a hedge strategy. The development of science and technology is, in itself, unpredictable in many instances; and, consequently, possible future breakthroughs in prevention and restoration technology should be able to be adapted into whatever kind of program may be underway. In this regard, however, it should be pointed out that as various programs reach maturity in the accomplishment of their objectives, the change to "more effecient" technologies becomes more difficult because the total benefit to be derived is more limited. Therefore, in the development of new technology to improve efficiencies over existing state of the art in restoration and prevention techniques, the largest advantage is to be gained if developed and implemented as early as possible in the program. It would appear that the \$4-5 billion cost outlook for pollution prevention and restoration program for Lake Erie would merit some further R & D to decrease that cost through development of more efficient technologies.

Other questions associated with the application of new technologies need to be answered in addition to the outlook for achieving certain targets. These questions concern the side effects which may also result from these technologies. For instance, in considering the potential of artificial destratification in formulating priorities and strategies for restoring Lake Erie, a large number of technical questions must be considered:[1]

- Can the results of destratification be adequately predicted?
- Will the results of destratification all be beneficial or can adverse ecological and chemical imbalances result either temporarily or permanently?
- What will be the downstream effect on Lake Ontario?
- What other restoration technologies should be applied concurrently to obtain the desired effect?
- What is the time-frame involved?
- What is the next level of engineering refinement necessary?

Our key concern with the list of recommended measures is to identify those which directly involve marine science and engineering and, where possible, to assess their priorities. Table 3, as an example, represents a summary of the preventative water pollution control needs in the Lake Erie Basin developed by the FWPCA. The measures which have important implications for marine science and engineering are preceded by an asterisk. The next task that follows is to derive a set of priorities in carrying out these measures within the context of a marine sciences program. Additionally, there are many more indirect implications of measures in Table 3 which relate to marine science and engineering such as the development of in-lake pipes and storage tanks or bladders associated with "sewer construction", or the implications for shoreline protection associated with reduction of "urban and agricultural soil erosion." While the particular meausres

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[1] Great Lakes Restoration. . . op. cit. p. 50

TABLE 1

SUMMARY OF WATER POLLUTION CONTROL NEEDS IN THE LAKE ERIE BASIN[1]

Category	Need	Responsibility
Implementation of water quality standards and enforcement conference requirements	Sewer construction, Secondary treatment, Tertiary treatment, Phosphorus control, Equivalent industrial waste treatment	Municipalities, Industries, States, and FWPCA
Intrastate Control Institutions	Area-wide development plans, Regional authorites, Intrastate water quality standards	States and Metropolitan areas
Surveillance	* Development of data base in areas of greatest water pollution control needs	States, FWPCA, USGS
Evaluation	Review progress of municipalities and industries in abating pollution	States
Dredging Control	Develop and implement alternatives to lake disposal of dredged materials	U.S. Corps of Engineers, FWPCA
Oil and Gas Well Drilling	* Prevent any wastes from these operations from getting into waters of the basin	States and drilling industries
Research and Development	Research into — 1. Methods of tertiary treatment 2. Phosphorus control 3. Sludge disposal * 4. Cause of fish mortalities * 5. Role of bottom sediments in lake pollution * 6. Ways to prevent formation of oxygen deficient zones in lake 7. Control of soil runoff * 8. Eutrophication studies	Federal Government States, Industries, Universities, Local Government
Erosion Control	Reduce urban and agricultural soil erosion	Soil Conservation Service, Bureau of Public Roads, U.S. Corps of Engineers, Other Federal, state, and local construction agencies

1 The table summarizes the immediate and long-range actions needed for pollution abatement control in the Lake Erie Basin. The immediate actions indicated are based primarily on the requirements to meet the interstate water quality standards established by the five Lake Erie Basin states, similar requirements on intrastate waters, and the requirements of the Lake Erie Enforcement conferences.

Source: Federal Water Pollution Control Administration, Great Lakes Region, Lake Erie Report: A Plan for Water Pollution Control, U.S. Department of the Interior, Washington, D.C., August 1968, pp. 68-69.

*(Asterisks denote activities directly or indirectly related to marine science & engineering).

(Table 1 continued)

Category	Need	Responsibility
Training	* Better and more training for all phases of water pollution control including treatment plant operation	State, Federal Government, Industry, Institutions, Local Government
Strengthen State Pollution Control Program	Increased 1. Enforcement 2. Training * 3. Technical assistance * 4. Research 5. Direction 6. Supervision of treatment performance * 7. Planning for water quality management	Governors and State legislatures increase manpower and financing of state pollution control programs
Financial	Increased financial aid for areas needing pollution abatement facilities	Federal Government, States, Local Government, Industry
Coordination with Canada	* Pollution abatement for entire lake	States, Federal Government, IJC, Canada
A Look Ahead	* New authorities and water quality management institutions for organized and efficient pollution control	States Federal Government

designated with an asterisk overlap with the interests or technologies of marine science and engineering, it is recognized that the particular agencies such as the FWPCA and the Corps of Engineers identified in the Table 3 example will likely continue to have lead responsibility in carrying out the indicated measures. Other measures subject to a broader spread of responsibility in the Federal Government may have direct implications for a marine sciences program responsibility--such as R & D in eutrophication and oil and gas well drilling. In the event of the establishment of a continued organized program of marine sciences in the Federal Government, (institutional) arrangements may be incorporated to provide the needed marine science and engineering support to these measures in terms of technical assistance, provision of R & D, or assumption of certain operation responsibilities.

One conclusion we have reached, however, is that the prospects for restoring Lake Erie appear reasonable enough to merit further exploration and demonstration of the scientific and engineering feasibilities of the measures identified in the Great Lakes Restoration Report. Since the restoration measures fall more directly into the purview of marine science and engineering, the restoration component of the water quality problem should be a major concern of a national marine science program (in close cooperation with the FWPCA and U. S. Army Corps of Engineers) as it addresses the problem of achieving optimal use of the coastal zone of Lake Erie.

Institutional implications of water quality control measures.--There is increasing activity by all levels of government in the Great Lakes Basin toward solving the problem of water pollution. In this regard Hennigan calls attention to "a singular lack of cohesiveness and unity in all this activity."[1]

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[1]Hennigan, op. cit..

He further notes that the Federal Government plays numerous leadership roles, including technical and financial assistance; the focusing public attention on water pollution problems through enforcement conferences; conducts studies and surveys, supports research; and functions as a "goad" to state agencies. While constitutionally and traditionally the fundamental program responsibility for water quality control resides with the states, the legal and administrative (including financial aspects) processes of state and local governments have been slow to respond to the problems fo pollution and its far-reaching impact.

The institutional role of the Federal Government stems from the urgent need for a cohesive approach to developing a many-faceted program action on the part of two nations as well as a multitude of problems arising from the complexity of Federal, state and local jurisdictions and responsibilities. The execution of Federal leadership in establishing an institutional framework within which the jurisdictional authorities may be coordinated (both politically and functionally) into a more effective water pollution central program would encompass the following elements:[1]

(1) An acceptance of this direct leadership responsibility by the Federal Government.

(2) Creation of a federal instrumentality responsible for water resource and water quality management on the Great Lakes.

(3) Intergration of all federal programming, more particularly of all FWPCA program elements.

(4) Establishment of federal receiving water and effluent standards applicable to all the international waters, including waste from watercraft and dredgings.

(5) A federal surveillance and monitoring program on the Great Lakes.

(6) Sufficient financial assistance to states and localities to be meaningful as promised in the enabling statute.

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[1]Hennigan, op. cit..

(7) In all legal actions by the states, either hearings or court appearances, the Federal Government should be prepared and willing to officially join the state in such action on request.

(8) Evaluation of state and local programs against objective standards to insure strength, stability, and effectiveness.

It is stressed that the Federal role can be most effective in initiating leadership in intergovernmental cooperation, as provided for in the Water Quality Act, and which in addition contains provisions for cementing a coordinated effort through financial support. Indeed, in terms of the national interest in optimum use of the coastal zone, the Marine Sciences Council has a stake in encouraging and strengthening the efforts of the Federal Water Pollution Control Administration in working with the states, local government and industry to achieve objectives for clean waters in the coastal zone of Lake Erie and Lake Superior.

Under the provisions of the Water Quality Act, a series of enforcement conferences was held around Lake Erie, and the states have recommended standards which have received the approval of the Secretary of the Interior. The states now have until 1972 to meet these standards. The first enforcement conference for Lake Superior is scheduled for May 1969. While the dumping of taconite tailings into the lake was the main impetus for holding this conference, a preconference report from the FWPCA precludes much action being taken to curb the dumping.[1] The FWPCA preconference report, which makes a total of 20 recommendations, calls only for "continued surveillance" of the discharge with reports to be made at six-month intervals to the conferees on whether pollution is indeed occurring. Among the other recommendations:

- Secondary treatment for municipal waste and the equivalent for industrial wastes should be provided by January 1973.
- By the same date, 80% of phosphorous should be removed from wastes.

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[1]Air and Water News, May 12, 1969, pp. 1-2.

- o Combined sewers should be separated or their pollution controlled by October 1977.

Efforts of state governments to develop an effective thrust into water pollution control are additionally having to overcome problems of internal co-ordination, and agreement on policy objectives and jurisdictional responsibility between state agencies, the states themselves and with local government. For instance, a legal inconsistency is seen in the case of Michigan, where the state's Attorney General ruled it illegal for the State's Water Resources Commission to grant an order to permit a mining company to pump chloride-bearing water out of an underground copper mine into a creek flowing into Lake Superior because it would violate the State Constitution's provision calling for "the protection of the air, water, and other natural resources of the state from pollution, impairment and destruction."[1] The problem of a generally inadequate revenue base of state and local governments to finance water pollution control activities is becoming of critical concern.

The 1965 water resource program enacted in Wisconsin is considered to be a good example of planning a coordinated effort to deal with the problem of water pollution and encourage optimum use of the coastal zone. The program provides for floodplain and shoreline zoning, financial and technical assistance to local government and industry, and coordination of water use, management and protective activities. Among the provisions of Wisconsin's act are:[2]

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[1] "Rules C&H Can't Pollute Hills Creek", Washington Post, Washington, D. C., January 29, 1969

[2] Hon. Warren E. Knowles, Governor of Wisconsin, "Pollution: How Wisconsin's New Law Speeds Compliance to Clean Up Waters," Nation's Cities, March 1969, p. 38.

- Consolidate state water responsibilities on one department. Water policies are formulated by a seven-member board and are implemented under the direction of an unclassified director appointed by the board.

- Organize water management regions to utilize technical staff in the most effective manner. Regional advisory boards will facilitate two-way communication between the state and localities and will provide public participation in setting water quality standards and solving other water problems.

- Provide financial assistance to accelerate the construction of pollution prevention and abatement facilities. A $25,000,000 annual state program of interest-free loans for communities will generate a $300,000,000 pollution abatement effort to supplement the $2,000,000 annually granted by the Federal Government to Wisconsin communities. Two incentives are provided to encourage further industrial participation in our pollution abatement effort.

- Plan water use, management, and protection. Long-range comprehensive planning insures proper utilization of our waters and enables periodic review of our water resource programs.

- Establish criteria to balance the various uses of water (e.g., domestic, industrial, recreational, agricultural) and develop standards to assure the proper quality is available for these uses.

- Control pollution by identifying sources of pollution, issuing orders to correct that pollution, and implementing control through enforcement where needed. In cases of non-compliance, the state may construct the necessary facilities and bill the owner accordingly.

- Zone lands to prevent pollution. Technical and financial assistance is provided to enable local governments to establish shoreline and flood-plain zoning ordinances. The state is authorized to prepare such ordinances if local ones are not enacted.

- Supervise proper operation of sewerage facilities and the installation of septic tanks by licensing sewerage plant operation and granting permits for septic tank installation.

- Research new ways of abating and preventing pollution. Accelerating our research activities and coordinating all state water research efforts will focus greater attention on our water problems and the development of necessary means to solve them.

- Regulate water quality and water structures to insure proper development and management of our water resources.

The Ohio Water Development Authority and the New York Pure Waters Authority also are worthy attempts toward solving the problem of water pollution. Here again, however, the effectiveness of the programs with respect to Lake Erie will depend upon the extent to which they coordinate with each other and the financial support they receive. In the efforts of states to enact programs to treat water pollution, particularly within the context of the broader interests of basin or coastal zone resources management, the Marine Sciences Council could provide a valuable contribution to state government through establishing coordinative guidelines of Federal activities in the Marine Sciences which will aid in achieving optimum use of the coastal zone.

With respect to the institutional problems of local government in water pollution control, Hennigan states:[1]

> The first step is consolidation of the existing collection and treatment administrative units. (This does not necessarily mean total integration of physical facilities.) Water and drainage responsibilities can then be brought in at a later date. The New York State, 100%-supported comprehensive water and sewage works planning program has been an effective device in many instances in accomplishing this objective.
>
> A single independent agency charged with the responsibility for providing water, sewage, and drainage service to a metropolitan area would be large enough to develop a high-level professional staff; to establish an effective rate schedule; to provide needed services in a timely, economical manner; to resist the varying winds of partisan politics; to provide economies of scale; to overcome boundry limitations; to serve industry; to effectively regulate industrial input; to provide for proper development of the water resource; and to insure high-level treatment of waste water to prevent continual deterioration of the water resource.
>
> This approach would also have the advantage of producing maximum revenue, leveling out coast differentials, lowering the need and demand for outside assistance, establishing a base line for reasonable charges for service, and establishing need, or lack of it, for outside fiscal assistance.
>
> The foundation of this approach is that water supply, sewage, and drainage are complementary parts of a single water system and, furthermore, that they are essential utility services, not optional governmental services. Consequently, these services essential to urban living will not compete with other needed services for limited "ad valorem" tax revenues.
>
> Outside assistance should be tied in with local action to develop a feasible and workable organization and financing scheme.

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[1]Hennigan, op. cit..

While the above statement provides an analysis of the specific needs of local government to organize more effectively to attack the problem of water pollution, there is a possibility that the process of coordination may break down when independent financing procedures as described above are practiced. Although it is frequently true that independent efforts to develop a funding base in the face of priority needs may be more successful -- as will also be discussed in the following section in the case of port authorities -- the administrative and operational authority which may be associated with such independent financial procedures may not lend well to achieving the degree of coordination with other land and water-related resource management programs. For instance, the efforts of the Federal Government to combat poverty and unemployment, particularly in the cities, has a relationship to water quality programs. Regardless of the level of government sponsoring the specific projects, the Marine Sciences Council may wish to encourage the advantages of coordination in line with the overall national interest in achieving optimum use of human and capital resources in the coastal zone.

The water pollution problem and the poverty problem are related through the appropriation of large sums of money for sewer construction, particularly in the larger metropolitan areas around Lake Erie since it is estimated that 25 cents of every dollar spent on sewer lines or treatment plants goes for direct wage payment, and half of this goes to unskilled or semi-skilled workers.[1] Additionally, the unskilled tasks in sewer construction come first; so that as work progresses, it could provide an unskilled worker with on-the-job training to become an apprentice carpenter or bricklayer.

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1 "Poverty, Pollution, and Sewers", Trans-Action, September 1968, p. 5.

To achieve the dual benefits of water quality control and anti-poverty measures, such construction projects should be subject to a process of public works coordination included with local, state, and regional comprehensive planning programs. More specifically, coordination measures should be identified in initial planning and budgeting proposals in preparing submissions for technical and financial assistance programs of the Federal Government. This is particularly desirable whenever multi-agency funding is required to be spread out according to the benefits which may be achieved or in identifying priority justification for single-purpose projects which indirectly have a wider range of benefits. Too often, opportunities in public works coordination are not utilized because of: (1) the single-purpose nature of the lead agency (which may also be an autonomous district or have a strong political constituency), and (2) the pressure for immediate project commitments (e.g., in the face of public pressure, credit markets, critical nature of the problem). The attempt to recognize multipurpose benefits of a public works project after the implementation stage is started, or is close to being committed, is severely limited in the extent to which the other benefits can be accommodated into construction schedules or operations.

Canada also is seriously concerned over water pollution. While the scope of the problem and its most appropriate solutions continue to be studied, corrective efforts (some unprecedented) are now being made. Recognizing that industrial wastes are becoming an increasingly dominant source of fresh water pollution in Canada, the 1965 Federal budget proposed a 50% tax deduction on capital expenditures made before the end of 1966 to prevent water pollution. This represented the first effort on a Federal level to deal with industrial pollution.

Apart from what is done in each country separately, the quality of Canadian-American boundary waters including Lake Erie and Lake Superior and the connecting channels is a principal concern of the International Joint Commission. Indeed, it may be considered its chief concern since the first criterion for assessing projects related to water quantity is their effects on domestic water supply and sanitation. The IJC's work on pollution began rather slowly before 1920 with a long period of study and apparent governmental reluctance to take decisive action. Since the war, however, the Canadian and U.S. Governments have developed the practice of implementing numerous IJC recommendations by joint surveillance boards.[1] Presently, the IJC is studying pollution in the Great Lakes, for which the Governments' Reference is given Appendix E.

While the outcome of all this concern over the Great Lakes situation cannot be predicted in detail, it appears likely that both countries will emphasize two concurrent approaches to pollution abatement. First, there are bound to be difficult and costly efforts to curtail the discharge of insufficiently treated wastes into the lake system, especially into the Detroit River and Lake Erie. Secondly, there will be concern over adequate flows of water through the lakes to dilute untreated or untreatable wastes. This will certainly influence the IJC recommendations concerning the best way to control excessive fluctuations in levels and flows on the lakes. The pollution problem also strengthens the arguments of those who contend that the full range of problems on the Great Lakes cannot be solved by merely manipulating the available water but will require additional water to be diverted into the lakes.

The Boundary Waters Treat of 1909 prohibits pollution in either country to the injury or health or property in the other. The International Joint Commission's involvement in problems of pollution of the connecting channels of the Great Lakes system dates from 1951 when the Governments of Canada and the United States accepted the water quality objectives recommended by the Commission in maintaining these waters in satisfactory condition.

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[1] Lea, <u>op. cit.</u>.

The Lakes Superior-Huron-Erie Advisory Board on control of pollution of boundary waters has recently repotted on the current status of pollution and of pollution abatement in the St. Marys, St. Clair, and Detroit Rivers. The Board reviewed this problem at the request of the IJC because of its concern over the continued degradation of water quality on these international waterways. The Board's Summary Report on Pollution of the St. Marys, St. Clair, and Detroit Rivers released in November 1968 stated that phenol and oil concentrations in all three reivers, coliform concentrations in the Detroit and St. Clair Rivers, and iron concentrations in the Detroit River fail to meet the water quality objectives established for these waterways by the Canadian and U.S. Governments. Additionally, oil, floating solids, and discoloration are serious problems; aesthetic values are being adversely affected; and wastes discharged from ships and pleasere boats using these waters aggravate the pollution problem.

The International Joint Commission convened in January 1969 public international meetings at Windsor,Ontario and Sault Ste. Marie, Michigan in order to develop an informed judgment on: (1) the adequacy and effectiveness of the pollution abatement programs referred to in the summary report, (2) why the established water quality objectives are not being met, (3) additional measures that might be taken to accelerate or improve abatement, and (4) ways of minimizing pollution in the interim before the scheduled control measures take full effect. At these meetings, the pollution control agencies and enforcement authorities having jurisdiction in each country and municipalities and industries involved were invited to describe the abatement programs they have under way and their timetables for achievement of the water quality objectives in the Detroit, St. Clair, and St. Marys Rivers. It was found that the Detroit River was in the worst condition,where most of the pollution/ comes from the U.S. side.

While the Canadian contribution is less in total volume, much of its sewage is discharged untreated. On both sides of the river, however, treatment plants and sewage systems are being built that should cut pollution beginning this year.[1]

For the St. Marys River, the situation "continues to be unsatisfactory because of the discharge of waste materials (particularly oils, phenols, wood chips, and iron) from two large Canadian industries (steel and paper)..." Both companies have scheduled abatement programs.[2]

For St. Clair, considerable improvements have been made with discharges from 5 to 11 major industries on the Canadian side conforming to Ontario Water Resources Commission objectives. The other six have abatement programs under way or plans under discussion with the Ontario Commission.

As a procedure to insure that the remedial measures necessary to achieve the objectives would be put into effect, the IJC is authorized to maintain continuing supervision over the pollution of these boundary waters. Accordingly, the IJC keeps itself currently informed of conditions through periodic progress reports from the advisory boards that were established for this purpose, through personal inspections, and of the Federal, state, and provincial programs in both countries which have been developed to control and abate pollution of these waters -- particularly those programs of the U.S. Federal Water Pollution Control Administration, the Michigan Water Resources Commission, and the Ontario Water Resources Commission. The IJC hopes and expects its efforts will serve to mobilize more effectively the efforts of all concerned in a concerted attack upon the serious situation in these

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1 Air & Water News, March 3, 1969, p. 2.

2 Ibid..

waters which are of such importance to citizens of both the United States and Canada. Appropriately, the Marine Sciences Council should consider the findings and recommendations of the IJC as it is presently constituted (or as it may be constituted in the future) in developing its position of encouraging and assisting a more effective approach to water quality control in Lakes Erie and Superior.

The construction grant program contained in the water quality program is a powerful tool in providing incentives to combat water pollution. However, the Interstate Conference on Water Problems pointed out the problem of bridging the gap between the authorizations for Federal construction grants and the much lower amounts appropriated by Congress.[1] Controversy over efforts to find a reliable means of making the actual amounts of available funds more commensurate with Congressional authorization centers around a number of issues:

(1) To what extent should the Executive Branch (i.e., the Secretary of the Interior) be able to make contracts committing the Federal Government to payment of the Federal share of the principal and interest on state and local bonds issued to finance construction of pollution abatement facilities?

(2) Should income derived from (federally financed) bonds be stripped of the normal tax exemption attached to state and local obligations?

(3) Should the use of the/contract procedure foreclose a state from availing itself of the prefinancing reimbursement provisions of the present water pollution control statute?

(4) Should Federal contracts be only for payment of the principal amount of bonds?

(5) Should state and local governments assume the full cost of interest of the Federal share, in addition to paying the state and local share of Federally-aided projects?

Since the Marine Sciences Council is concerned with the optimum use of the coastal zone, it will no doubt be concerned with the discussion of measures involving

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1 "Summary of Proceedings, Interstate Conference on Water Problems", October 1968, Council of State Governments, Washington, D.C., p. 4 (Unpublished).

Federal cost-sharing for water quality control, particularly with respect to assuring that proper incentives are included in the policies for coastal zone priorities in water pollution abatement. In addition to the provision of grants for water pollution abatement facilities, Federal loan practices for water resource development and water quality control need to be better coordinated. Of importance to loan practices in which cost/benefit formulas are used is the manner in which repayment schedules are formulated. A Water Resources Council Task Force will be reporting shortly on improvements in evaluating water resources projects. Also, the Bureau of the Budget is preparing a circular to guide the use of discounting procedures to better evaluate programs. The Marine Sciences Council should review these reports carefully in order to determine the impact of Federal lending procedures on encouraging large-scale, long-range commitments to public works projects for water pollution control by state and local jurisdictions. Of particular importance is the tendency for higher discount rates to make borderline projects "uneconomic" and give preference to projects which have an early economic return over those which have long-deferred benefits, or benefits of an intangible nature such as water quality. The Marine Sciences Council should develop recommendations to the WRC and the BOB for lending conditions and practices to give priority to and encourage water projects of the widest range of benefits which could accrue to the coastal zone. With regard to the extent to which the costs of water quality control should be allocated, Hennigan has developed the following evaluation of this question:[1]

> The cost is eventually borne by the public no matter what technique is used to raise revenue. Revenues should be based in some rough way on the direct and indirect benefit accruing to the users and raised in the manner least likely to cause opposition and most likely to develop project support. To be successful, the entire effort must be evaluated to insure that Federal, state, and local efforts will, in fact, reach program objectives.

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1 Hennigan, op. cit..

It is my feeling that optimum programming at all levels without a meaningful infusion of financial support cannot be successful. On the other hand, massive infusion of money for facilities construction without strong programming will not be successful; experience has demonstrated this. Both meaningful outside financial support coupled with strong federal, state, and local programming are needed for a successful effort.

Arguments can be advanced for almost any allocation of costs from 90% federal; 10% state and local, as in the highway program; to 100% local with no federal or state assistance. The former is successful because of the highway fund and the overriding national and state interest. The latter has been a failure because of lack of recognition of national and state interest and limited local financial resources. The proper allocation probably lies someplace between the two extremes.

In the face of no overriding evidence to the contrary, a 30% federal, 30% state, 40% local share of treatment facilities cost is a fair allocation if no ceilings, either on individual projects or on available funds to meet schedules, exist. This recognizes the national, state, and local interest and will not function as a deterrent to moving ahead as has been and is the case now.

Under the present Federal cost-sharing program, sewer costs are non-eligible for Federal grants. Since sewers account for about 50% of municipal needs, this still means that under a 30-30-40 allocation formula the total cost burden would be 15% Federal, 15% state, and 70% local. It is also questionable if the Federal Government could meet the 30% cost-sharing commitment -- even though provisions allow for up to 55%--under present financial burdens. This indicates that the burden of responsibility will continue to fall on local and state governments to meet water quality control costs, particularly for those facilities needed in the next 3 to 5 years to meet adopted water quality standards.

The elements to be considered in striving toward achieving an operable 30-30-40 cost-sharing formula include:

(1) Priority consideration or elegibility on the basis of need,

(2) Application (largely Federal) of R&D to lower costs,

(3) Provision of long- term, low interest rate loans

(4) Redistribution of revenue-producing tax bases, as has been under consideration by the Council of State Governments, National Association of Counties, and National League of Cities, involving, for instance, the

institution of block grants from the Federal Government to state and local governments.

From the marine sciences standpoint, the Marine Sciences Council should seek to assess the impact of water quality control measures on the various aspects of oceanographic and limnological activities with which the Council is concerned in order to provide the basis for an economic evaluation of the benefits which would accrue to these activities with an increase of water quality (or diseconomy, if present quality levels are maintained or continue to be reduced). This assessment would be of value in developing a policy position on the part of the Marine Sciences Council on the question of the role of the Federal Government supporting technical and financial assistance in water quality control. In other words, the Marine Sciences Council should be able to report on the contribution that clean waters could make to the national oceanographic effort, particularly with respect to optimum use of the coastal zone.

Another overall national problem in water quality management which is particularly manifest in Lake Erie is that conventional waste treatment plants using a conventional waste treatment process fail to eliminate at least 10% or more of the suspended solid wastes and other organic matter.[1] They cannot remove the complex materials left over from manufacturing new products, such as plastics, detergents, and pesticides. Half of all industrial wastes today contain chemicals that did not exist 10 years ago.[2] The minerals and other nutrients, such as phosphates and nitrates, nourish growth of algae and other offensive organisms in the receiving waters.[3] More Federal assistance for R&D in pollution abatement is needed both to increase the effectiveness of waste removal and to further lower the cost of

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[1] Jones, op. cit..

[2] Smith, R. C., "Industry's Responsibilities for Water Pollution Abatement", Journal of Soil and Water Conservation, September-October 1966, pp. 177-179.

[3] Jones, op. cit..

conventional treatment plant processes and the cost of other waste removal technologies which are presently uneconomic to use. More specifically, further research is needed in identifying harmful constituents of industrial waste, particularly those which contain:[1]

(1) Toxic materials dangerous to aquatic life and to men.

(2) Mineral substances which complicate the sewage treatment process when discharged into municipal sewage systems.

(3) Large quantities of organic substances that deplete oxygen in receiving water.

(4) Huge volumes of heated water which raise the temperature of receiving waters and thereby frequently destroy all but the hardiest of organisms.

Water in the Ruhr River in Germany is maintained at a quality standard that meets the needs of both industry and recreation. This standard is maintained through a cooperative agreement between the 250 cities and 2,500 industries to treat waste waters on the simple principle of "whoever uses the water must pay a charge for its purification."[2] Similarly, the Water Quality Act makes it clear that industry is expected to control their pollution without public financial assistance. As waste control investments are direct costs of operation, industries are faced with uncertainty as to whether the costs of pollution control will reduce profits or whether these costs can be passed on to consumers much as can various kinds of taxes if registered uniformally among competing firms. In some cases, new waste treatment processes may eventually yield useful by-products which might offset at least part of the cost of pollution abatement.

Reliable data on costs of these kinds of processes would be desirable for each industry, but are usually unavailable. The cost of control equipment is often

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[1] Ibid..

[2] Smith, op. cit..

included in new plant appropriations or buried in regular maintenance budgets. However, a wide variety of companies say their pollution abatement expenditures average 5% or less of overall capital spending.[1]

Congress has made funds available to cities and other governmental units for construction of pollution control projects. There is no money in the program for industry. This may retard the progress of pollution control and may also force a different situation on a company which has limited funds available for capital expansion. Financial institutions are hesitant to loan money for capital investments which do not generate additional income. Investments in waste control plants fall into this category.[2] Additionally, some difficulty has been created in setting standards for individual industries in Lake Erie because of the lack of data to establish uniform standards for all industries. This has created problems in that wherein one company is forced to expend large sums of money for R&D and pollution control, his competitor may spend nothing and, ultimately, also benefit from the new technology by applying it only for capital cost (less the initial R&D). Individual concerns have been reluctant to install costly waste processing plants required to control pollution without some assurance that competitors will also assume this added cost of operation, including foreign competitors in certain industries under pressure of growing imports.

Another difficulty of industrial pollution control is that most industries produce unique waste products. Consequently, other than basic pipe, pumps, and other fixtures, there is little opportunity to develop "off-the-shelf" pollution

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1 "Industry Joins Battle to Stem Pollution Tide", Business Week, December 31, 1966, pp. 76-77.

2 Smith, op. cit..

abatement equipment. Each industry must develop its own waste management system, requiring in most instances a substantial R&D outlay in the design of a tailor-made system. One advantage, however, is that many industrial control systems are much smaller than minicipal systems and can be built quickly without the red tape involved in public construction. Another approach to industrial waste management is that it may be more economical to change the process of production bringing waste content down to acceptable levels.

There may be certain areas of industrial pollution control that the technological or financial prospects for pollution abatement are extremely dim throughout the industry. In these cases, it may be appropriate to reconsider the original concept of the Water Quality Act to determine the extent to which it is in the public interest to subsidize the R&D or treatment of industrial waste from that particular industry. Approaches to assisting industry, some of which involve amending the Water Quality Act, include:

- o Providing long-term, low-interest loans.
- o Granting of tax credits and rapit deprecation allowances for capital investment in pollution control equipment, which would also be useful in encouraging re-investment in new pollution control equipment as new products cause waste control plant obsolescence.
- o Subsidize the construction of municipal sewage treatment plants built to have extra capacity and equipment to accommodate municipal sewage. While industry may be taxed a service charge, they would avoid the capital outlay and perhaps a portion of the R&D costs.
- o The Federal Government bearing up to $1 million, or 70% of the cost of research on industrial waste problems for any single research project which would have industry-wide application.

As the matter of providing incentives to private enterprise in the development of ocean resources is of significant interest to the Marine Sciences Council, it follows that there may be certain areas of water quality control--either in actual abatement practices or in the pollution control service and equipment industry--

where the national interest would be served with some form of incentive to industry. While this problem has only been touched upon above, the Marine Sciences Council should be encouraged to pursue this question further; and, if such a justification would be forthcoming, indeed the pollution crisis in Lake Erie would merit priority attention in encouraging and assisting industry to meet their water quality control obligations.

Recommendations for water quality and control.--Based upon analysis of the list of recommended pollution prevention and restoration measures and the discussion of other quality control problems, four primary overall recommendations for measures in marine science and engineering have been distilled. The recommendations refer to the execution by a functional operating or coordinating agency of the Federal Government concerned with marine sciences. This agency may be either the National Council on Marine Resources and Engineering Development or such agency as may be ultimately established or designated to carry out such functions. The basic structure of the recommendations for water quality control are described below.

(1) It is recommended that first priority be given to the problem of water quality in consideration of measures for promoting the optimal use of the coastal resources of Lakes Erie and Superior.

(2) It is recommended that priority attention be given to providing marine science and engineering support to the Federal Water Pollution Control Administration and other appropriate Federal, state, and local agencies and institutions and private entities in the prevention of water pollution and the achievement of water quality standards adopted within the Lake Erie and Lake Superior Basins. In this regard, priority consideration should be given to the following measures:

A. R&D to facilitate collection and treatment of municipal and industrial waste and urban run-off waters through the use of inlake pipes and storage tanks or bladders.

B. Development and implementation of alternatives to lake disposal of dredged materials and control of sediment disturbances in excavation operations.

C. Prevention of waste or other ecological disturbances from oil and gas well drilling and other mineral excavation operations from getting into the waters of the lakes and effective remedial measures to mitigate the effects of such pollution in the event of uncontrollable accidents.

D. Conduct of R&D into the cause of fish mortality and degradation of other plant and animal wildlife and implement measures leading to water quality management.

(3) It is recommended that priority attention be given to the initiation of a program of restoration of Lake Erie to a condition commensurate with water quality standards adopted for the Basin. The restoration program should be considered as a measure to augment the efforts of the FWPCA, state, and local governments and private entities to prevent further pollution of the Lake and should:

A. Be considered as an element of, and contribute towards the accomplishment of, an integrated comprehensive program of waste management of the Lake Erie Basin (and the Lake Superior Basin).

B. Give priority attention to studies of the process of eutrophication and accelerated aging of the lake, particularly with respect to the role of bottom sediments in lake pollution; developing ways to prevent formation of oxygen-deficient zones in the lake and other methods of restoration; and developing methods of algal removal in near-shore waters.

(4) It is recommended that there be established a program of environmental monitoring in the coastal zone of the Great Lakes Region with priority given to implementing the system initially in the Lake Erie and Lake Superior Basins. The environmental monitoring system should:

A. Augument and coordinate where desirable existing monitoring activities of governmental agencies, research institutions, and private industry.

B. Include atmospheric, surface, sub-surface, bottom, and sub-bottom perimeters.

C. Be designed as a federated, as opposed to a centralized, system for collecting and distributing data to maintain as much flexibility as possible and, at the same time, achieve standardization in coding data to facilitate compatibility of data storage for a variety of uses.

D. Give first priority to information needs for better water quality control operations.

There are two significant <u>institutional policy implications</u> with respect to the pollution prevention and restoration measures for Lake Erie and Lake Superior.

The first of these concern the legislative and financial frameworks being developed by the states adjacent to Lake Erie and Lake Superior to establish standards and carry out programs to implement those standards pursuant to the Water Quality Act of 1965. In addition to the assistance available from the FWPCA under the Water Quality Act, it would benefit these efforts if a certain amount of technical and financial assistance were available through the aegis of a national marine sciences program, including the National Sea Grant College Program, to aid states and local governments in those particular measures lying in the realm of marine science and engineering. For instance, the R&D and capital requirements to develop large-scale and more efficient pollution prevention and restoration systems -- particularly with regard to the aspects involving marine science and engineering identified in the recommendations on the two previous pages -- may be beyond the more short-range oriented financing capabilities of state and local jurisdictions. This is particularly true for the western end of Lake Erie (i.e., from Cleveland on around to Detroit) where the more intensively developed shoreline and the shallower lake waters would appear to make in-lake collection and storage facilities an attractive alternative in developing metropolitan area and even regional sewer collection and treatment systems. Additionally, an important policy question exists as to the extent to which there may be national interest in providing R&D and low-cost loans to states and local jurisdiction and industries to achieve the water quality standards adopted for the region by 1972 and for the initiation of a restoration program.

The second institutional policy implication of water quality and control measures concerns the role of the National Sea Grant Program. As R&D is an important part of developing the methods and hardware to solve the problems of pollution prevention and restoration, the National Sea Grant Program would appear to have a role in augmenting the educational and R&D support requirements in the marine sciences needed to carry out the pollution abatement and restoration of Lake Erie and preservation of Lake Superior as envisioned by state and local government, industry, and the FWPCA and other Federal agencies. Rationale for such a role would, for example, focus on the eutrophication and restoration of the Lake Erie and preservation aspects of Lake Superior waters in supporting educational and R&D in the colleges and universities throughout the region. For example, the R&D needs that are characteristic of the high priority preventative and restorative measures for Lake Erie (including the attendant implications for other water uses and the more urbanized shoreline) would provide a rationale that distinguishes the priority needs of one lake from another. Additionally, the range of limnological and R&D and educational requirements for Lake Erie and Lake Superior would be applicable and beneficial to other Great Lakes and fresh water lakes throughout the United States having problems lying within the two extreme ranges of the two former lakes, such as Lake Michigan and Lake Huron.

Modifications of the Coastal Zone

Certain uses of the coastal zone by man modify the physical configuration of the shoreline and bottom of the lakes. The activities which affect the greatest forces in such modifications involve: (1) land fills; (2) dredging and excavation; (3) shoreline protection, including measures to stabilize erosion and sedimentation due to both natural and man-made forces; and (4) port and harbor development. Modifications in the form of structures to control the flow of waters and regulate lake levels are considered in the water management section of this report. Shoreline and bottom configuration modifications are conducted to carry out a variety of objectives ranging from dredging to maintain the depth of channels and harbors for navigation, to the creation of new industrial land through filling shallow offshore waters and construction of offshore breakwaters or shore erosion structures to protect the shoreline from erosion and siltation resulting from the forces of waves and currents. Basic problems associated with changes in shoreline and bottom configuration include:

(1) The development of better engineering technology and techniques and information about coastal processes to carry out modifications more efficiently;

(2) The minimization of undesirable effects of modifications, both to the local and lakewide ecology of the lake and to other purposes, interests, and uses of the shoreline, bottom, and waters of the lakes;

(3) The maximization of the fullest or widest range of benefits to the coastal zone from modifications (which may eminate from either single-purpose or multi-purpose uses).

To achieve optimal use of the shoreline -- as such use relates to physical modification of the shoreline -- requires an institutional arrangement within which planning, coordinating, and constructing of modifications may be conducted to accomplish the above three objectives. Federal interests are essentially administered on a problem or functionally oriented basis throughout the Great Lakes Region, such as the U.S. Army Corps of Engineers' harbor and channel maintenance program, the activities of the Bureau of Commercial Fisheries in fisheries management, or the FWPCA in water quality control. On the other hand, state and local interests are more jurisdictionally oriented to their respective political boundaries. The notion of regional planning and coordination is to achieve a coordinated interpretation of shoreline development objectives along the coastal zone in a manner consistent with the jurisdictional interests of state and local government and the functional responsibilities of the Federal Government.

Decisions for modifications of the physical environment at present involve a multi-stage course usually including several agencies or levels of government. For instance, the large reclamation proposal for a regional airport facility offshore of Cleveland will involve the approval of use under the zoning authority of the City of Cleveland (or County of Cuyahoga), the authorization of the use and modification of the lake bottom under the terms and conditions of the Ohio State legislature grant or lease to the airport construction agency, the review and granting of the fill or diking permit by the Corps of Engineers primarily for the purpose of maintaining navigation interest.

Except for some specific port and harbor development plans -- such as those prepared by the Ports of Toledo and Erie or the earlier (1962) waterfront plan of the Regional Planning Commission at Cleveland, there is no clearly defined policy or guideline set for modifications of the shoreline and bottom of Lake Erie or Lake Superior. This is, in part, due to the fact that consciousness of social, biological, and engineering aspects in the treatment of the lake has only been awakened in recent years. The International Joint Commission is now working on a shore protection study in cooperation with the Corps of Engineers, and both the IJC and the FWPCA are involved in studying and recommending measures to solve the pollution problem. Knowledge of the relationships between modifying coastal processes and the impact on lake ecology is inadequate; and consequently, it has largely been in response to the aftermath of problems caused by certain coastal engineering practices (e.g., the dumping of dredge spoils) that public and scientific awareness has demanded a closer look be taken at these problems.

Presently, the U.S. Army Corps of Engineers procedure for issuing permits for private construction in navigable waters serves as the main coordinating vehicle for physical modifications of the shoreline and lake bottom. Through the Fish and Wildlife Coordination Act and other interagency agreements with the Department of Interior and other agencies, the Corps has sought to expand considerations beyond navigation interest to assess the water-related construction activities on coastal zone ecology and accelerate its research efforts to develop new technologies and equipment for restoration of coastal shores. In Lake Erie, the Corps is testing different dredge spoil disposal techniques to reduce pollution and other damaging effects to the lake environment. This expanded authority is now being tested in the federal courts. Should the courts find that Corps permits cannot be denied on grounds other than hazards to navigation, then consideration of legislation to protect broader public interests may be warrented.[1] While the efforts to broaden the scope of the Corps of Engineers permit process are important, nevertheless, the planning, coordinating, and implementing of measures affecting the physical configuration should be conducted within the broad frame-

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[1] Marine Science Affairs (Washington, D.C.: Office of the President) January 1969, pp. 71-73.

work of a lakewide reclamation policy. Such a policy would be useful in providing general direction and guideline for considering the many jurisdictional interests and environmental repercussions of small and large scale modifications or reclamation projects. A reclamation policy would include the following elements:

(1) Recognition of the comprehensive planning programs of the respective local, state, and regional jurisdictions within which the project proposal originates.

(2) Recognition of the land use control authority of local governments.

(3) Recognition of the terms and conditions of state government executed in the grant or lease of the lake bottom.

(4) Recognition of pollution standards adapted by the states in the lake basin.

(5) Recognition of navigation interests of the Federal Government as well as other national interests as may be reflected in the granting of the Corps of Engineers construction permit.

(6) The assessment of impact of the proposed project on the ecology and coastal processes of the lake, including identification of those areas of unknown impact and other uncertainties.

(7) A process of informing interested agencies, organizations, and the general public of the impending proposal and enabling their expression of interest therein. (This process may include circulation and hearing procedures similar to the Corps of Engineers permit procedure.)

There are essentially two main alternatives for formulating and administering a lakewide reclamation policy. The first would be for an existing regional agency such as the Great Lakes Basin Commission to formulate a policy statement and review process as a part of its on-going comprehensive planning program for water and related land resources. As this planning program is a cooperative effort between the federal and state -- and ultimately, local -- governmental jurisdictions, the reclamation policy could be formulated as an integrated element of the program. The reclamation policy would be administered on an advisory basis as is, or will be, done by the Great Lakes Basin Commission in its regular advisory role. The reclamation policy would be available as a guideline to the various agencies and jurisdictions making decisions in order to achieve a rational approach to shoreline modification.

The second approach stems from the possibility of opposing interests in modification projects being expressed within certain elements of the reclamation policy, such as the recognizable need for offshore open space for an airport facility versus an equally recognizable need to preserve fish and wildlife habitats that would be jeopardized or eliminated if the airport space were reclaimed. As an advisory agency, the Great Lakes Basin Commission can provide the opportunity to achieve a consistent reclamation policy;or it can bring out into the open the conflicts of interests within a multi-stage, decision-making process as described earlier. However, as an advisory agency, its influence may not be adequate to bring about decisions involving trade-off of benefits or values with respect to opposing interests, or prohibiting one interest from overriding another (and not being held liable for the lost benefits).

It is nothing new that in some cases decisions reflecting local or single-purpose benefits, but which have negative value to a region, are implemented in the absence of a region-wide decision-making authority. While the desirability of a regional decision-making authority is recognized in many parts of the Great Lakes Region, the prospect of transferring existing authoritative prerogatives of local and state government or the Federal Government to such a regional authority is quite another matter. The creation of a regional authority -- with powers to either enforce actions or to veto certain actions endorsed by other levels of government -- can be based on setting up a regional body of elected officials from the region or, in essence, creating another "level" of government. An alternative is for the existing executive and legislative offices of state and local government to grant by compact agreement certain powers relative to regional matters to a regional authority. In this approach,a state or local government, for instance, would yield to the regional authority, say, the right to veto an action on the local or state part which would be harmful to the region. The management compact proposal prepared by the Great Lakes Compact Commission is an example of such agreement. While the execution of such a management agreement would be of great benefit to solving region-wide problems, the placing of the authority in one of the existing regional agencies -- which would seem to be a convenient step -- or establishing another management "authority" will be a highly sensitive political move with respect to the state and local participation. Although the Federal Government has an overriding national interest in the optimum use of the coastal zone of these lakes, there are many levels of decision-making with respect to achieving regional development objectives (e.g., as may be defined later this year in the Great Lakes Basin Commission planning program) that should appropriately remain at local and state levels. It is in this regard that some state and local interests fear regional authority in the Great Lakes Basin Commission because of the predominance of federal representation on the Commission. However, it should be possible to overcome this fear by careful design of the terms of the management compact agreement. Most important is the need for an establishment of a regional authority that will eminate from local and state government "upward" to a basin-wide authority which will include federal representation.

<u>Land fills</u>.--The filling in of shallow waters adjacent to the natural shoreline, or creation of offshore islands[1] or their extension, stems from the need for new land for urban, industrial, and port uses and for open space for disposing of river and estuarine channel dredgings and the waste of by-products of urban and industrial processes.

Decisions with regard to land fills along the shoreline are made largely on an individual or project basis for whatever purpose the respective agency or owner intends. As previously mentioned, about the only coordination of filling operations occurs through the permit review procedure required by the U.S. Army Corps of Engineers for modifications of the shoreline or bottom and construction of structures within navigable waters. Other controls affect land fills along the shoreline such as local land use control ordinances (zoning) and terms and conditions set by state granting or leasing authorities for the area to be filled. Some shoreline planning has been done by some cities such as Cleveland and Buffalo and, more recently, by Toledo and Erie in conjunction with their port development programs. However, except for the Cleveland <u>Lakefront Study</u> of 1962, these planning programs for the most part have not dealt with shoreline modification standards or plans and provide little overall guidance for reviewing or assessing the implications of individual port and harbor developments, dredge spoil or other solid waste dumping, or other fills out into the lake. Widespread attention has been given to the problem of pollution resulting from dumping of dredge spoils and other solid waste materials in fills, but here again the problem is being attacked on an individual problem-oriented basis.

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1 For example, Miami's new port at Dodge Island was created by an offshore land fill which offered several advantages over land fills extending from the original coast: proximity to deeper water and preservation of original coastal zone uses and recreational boating lanes near shore away from shipping lanes. Dodge Island is connected to shore by a bridge.

materials in fills; but here again the problem is being attacked on an individual problem-oriented basis.

The U.S. Army Corps of Engineers has authority over the modification, construction (i.e., piers, dikes), and dredging of the lake bottom and navigable channels and filling shoreline of navigable waters which dates back to the 1899 Act, "Laws for Protection and Preservation of the Navigable Waters of the U.S.". Individuals or organizations wishing to make such alterations are required to obtain a permit from the Corps of Engineers. Although its review of the application is primarily concerned with the effects on navigation, by Presidential executive order, other public interests are to be considered including pollution (water, aesthetic), and fish and wildlife.[1] The permit procedure involves circulation of the permit application, which includes a general description of the proposed project, to interested parties and the conduct of a public hearing. Applications for structures and projects not interferring with navigation may be approved at the division level. Proposals involving modification of the pier head or harbor lines or channel changes may require decision by the Chief of Engineers in Washington. Other Corps of Engineers projects are recommended by the Corps itself or by Congress and may consider a wider range of project costs and benefits including flood control, water flow regulation, and recreation.

Policy guidelines should be developed in the Great Lakes Basin Commission Study, the IJC Shoreline Protection Study, planning programs of the respective state planning agencies, and appropriate federal agencies (e.g., the Marine Sciences

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[1] Excerpt from Regulation No. 1145-2-303 - CIVIL REGULATORY FUNCTIONS Permits, Policy, Practice and Procedure (18 March 1968), p. 2.: Paragraph 4. Public Notice and Consultation with Interested Parties. d. ...The notice will contain a statement similar to the following: "The determination as to whether a permit will be issued will be based on an evaluation of all relevant factors including the effect of the proposed work on navigation, fish and wildlife, conservation, pollution, and the general public interest. Comments on these factors will be accepted and made part of the record and will be considered in determining whether it would be in the best public interest to grant a permit."

Council) to guide actions involving filling and other shoreline modifications. For instance, the Department of Interior is pressing for better environmental quality consideration in the Corps of Engineers activities and the Corps' review of other shoreline development and dredging activities. The Corps has been operating under an agreement with DOI to maintain dumping in their regular dumping areas located in an "approved" area several miles from shore in waters at least 50 feet deep. The purpose is to contain the spoil dumping in a limited area rather than scattering spoils at different locations.

The deposition of dredge spoils is a major problem in Lake Erie and Lake Superior. In the Corps of Engineers' responsibility to maintain channel and harbor depths, the bottom sediments from the more populated areas are polluted and are disposed of in "wet" form. While source materials are in scarce supply for land fills, dredge spoils are largely considered ppor quality, and often not available in sufficient quantity to use for major land fill operations. With respect to the latter, the scarcity of land fill materials suggests attention be given to development plans oriented away from the shoreline to accommodate "new land" needs or utilizing diking and draining methods to reclaim lake bottom lands. Dredging technologies could also be developed to obtain clean materials from the lake bottoms, as well as utilizing other solid waste materials such as slag or garbage.

The Corps of Engineers in 1967 initiated a $120 million program to build dikes around spoil dumping grounds adjacent to dredging operations to contain the spread of fine sediments. At the request of the Bureau of the Budget to determine the benefits of this pollution prevention program, the Corps started a $5 million test program to experiment and evaluate the results of different kinds of dredge spoil dumping methods, and to recommend acceptable and feasible disposal means in the lakes and diked areas adjacent to the shore. Included in the experimental program have been the testing of various diking materials, carriage water treatment and drainage methods, spoil handling techniques, and laboratory bio-essays on the impact of the sediments on fish and wildlife. The test site at Buffalo, New York, was made of dikes using slag materials from nearby steel industries. A test site was developed at Cleveland by constructing dikes with limestone rocks covered with a blanket of clay to make the dike impervious to leakage of spoil solids while permitting the carriage water to drain away. Filtering of spoils to separate solids from carriage water was also tried. Two test sites were utilized in Maumee Bay at Toledo, Ohio. One of these disposal sites had been established some years ago near the mouth of the Maumee River. The site was selected on the basis of convenience as a dumping site rather than a pre-planned land fill for use when developed. The site will revert back to the city when the fill is completed. The other test site at Toledo is located along the banks of the Maumee River.

Dredge spoil materials would be more sought after as a fill material if: (1) the organic pollutants could be effectively treated or contained, (2) the fine sediments could be treated to provide better settling and bearing strength characteristics -- and if efficient techniques could be developed to separate solids from the carriage water prior to dumping or to induce better (especially quicker) drainage inside of diked areas. The Corps of Engineers in these experiments has tried experiments with aerating spoil materials, adding slag mixtures, and -- as in Chicago -- even trying to run some spoil materials through a sewage treatment plant. While progress has been made in developing diking techniques to arrest pollution from dredge spoil dumping, a successful technique to render these materials into a better fill material has not yet been perfected. The Corps report on this test program will be released later this year.

An engineering study for the port of Erie, Pennsylvania, suggested an approach to filling a 45-acre area extending property of the City of Erie out to the harbor line. (The property would eventually be used for commercial-recreation purposes.) The approach called for enclosing the area to be filled by a system of dikes. Due to the high cost of dike construction and filling at the harbor line in the 16-foot average depth, an intermediate location along the property line where depths vary between 6 and 12 feet was selected as the outshore limit of initial filling operations. "The U.S. Army Corps of Engineers is presently seeking shorefront locations for disposing of the Erie Harbor maintenance dredge spoil and would probably consider using this area. Each year the Corps of Engineers dredges about 200,000 cubic yards of sediment in maintaining prescribed depths for the waterfront, harbor basins, and channel. Approximately half this amount (100,000 cubic yards) is dredged from the waterfront and harbor basins and consists of an organic silty material or mud." If this material is used for land fill, it will take many years for this fill to consolidate under natural conditions. However, the Corps is most anxious to dispose of this material in a way that would reduce its contribution to the lake's pollution problem. The other 100,000 cubic yards of material is dredged from the channel and consists of sand which would provide a relatively stable and easily compactable fill. It is possible that the Corps of Engineers could be induced to deposit the sandy spoil on the inshore portion of the area where it would be logical to expect any property development to begin, while the so-called "poor light waste" could be deposited on the outshore portion of the area where it could be left to consolidate.

Moreover, the consolidation process could be accelerated by surcharging with any dry material. In fact, the sandy dredge spoil could be used for this purpose after the entire area is filled. The entire area of 45 acres could be divided into two areas with a longitudinal dike system: the inshore area would be approximately

25 acres and the outshore area would be approximately 20 acres. If necessary, the system could be further refined with transverse dikes to facilitate early reclamation of special areas. Filling the inshore area with the sandy spoil material to an(average) elevation of 8 feet would require approximately 20,000 cubic yards per acre. Assuming that 100,000 cubic yards of this material were available yearly, then five acres of (new) land could be reclaimed annually, or 25 acres in five years. Filling the outer area to the proposed improvement line proposed in the Development Plan with the poor light waste would require approximately 29,000 cubic yards per acre. The additional yardage required in this area is due to greater depth. Assuming that 100,000 yards of this material were available yearly, then four acres of land could be reclaimed annually or 20 acres during the same five-year period. Shortly after the first year, building could probably commence on the initial five-acre inshore fill.[1]

Land fills of several thousand acres (or diking and draining) for supersonic transport airport facilities are being considered offshore of Cleveland (and Chicago).[2] These large-scale modifications would constitute major shoreline configuration changes and require extensive engineering and ecological study to guard against adverse environmental problems which may result (applicants -- such as the City of Cleveland) in preliminary discussions with the Corps of Engineers who have been advised that they will have to support their permit application with evidence of the impact of the filled or diked area on the lake ecology and other interests as well as "navigation". Projects of this scale should also require major policy decisions with respect to future pattern of urban growth and population distribution

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1 Waterfront Development Plan, Port Commission, Erie, Pennsylvania, April 1969, pp. 55-56.

2 Bloomfield, Douglas, "$1 Billion Jetport in Lake", The Plain Dealer, Cleveland, Ohio, February 13, 1969, p. 1,6.

in the coastal zone and hinterland of the region.

The dredge spoils collected annually from the Cleveland Harbor would cover an area of approximately 2 acres to an average depth of 150 feet. This source would not alone be adequate to provide fill for the 3,000-plus acre airport facility proposed for offshore Cleveland in any reasonable number of years. Again, alternative sources of fill or reclamation methods will need to be explored for such large-scale projects.

Cost figures for filling and diking in Table 1 would suggest that new land costs by either filling or diking and draining out to an average depth of 10 feet

TABLE 1

LAND RECLAMATION COSTS[1]

(Ground Elevation Plus 8 Feet)

	Source Material	Average Water Depth	Cost[2]
LAND FILLS:	Dredge Spoils	4 feet 10 feet	$ 5,000/acre 7,500/acre
	Fresh, Clean Materials	4 feet 10 feet	$ 20,000/acre 30,000/acre
DIKES:	Materials from Building Demolition	4 feet 10 feet	$ 15/lineal foot 30/lineal foot
	Fresh, Clean Materials	4 feet 10 feet	$ 40/lineal foot 75/lineal foot

1 Source: Waterfront Development Plan, Port Commission, Erie, Pennsylvania, April 1968, p. 70. (Estimates prepared for demonstration of cost ranges of land reclamation projects for Port of Erie, Erie, Pennsylvania).

2 In actual cost estimates, 15% should be added for engineering contingencies.

may be economically feasible along most urban shoreline reaches around Lake Erie and Lake Superior, comparing favorably with alternative land cost on shore. On this basis, it would appear that it is already technologically feasible to reclaim approximately 10% of Lake Erie and most of Lake St. Clair.

In the face of increasing urban pressure, particularly around the U.S. shoreline of Lake Erie, the need for a basin-wide reclamation policy becomes apparent. The results of filling, while serving these needs of various land and water uses, may either increase or decrease the length of the shoreline depending on the manner in which it is done -- although there are obvious advantages, for the most part, in increasing its length. Additionally,the change in shoreline configuration from filling may affect the circulation of nearshore waters. This may cause new patterns in erosion and sediment deposition or affect pollution by either increasing circulation and diffusion or alternatively by causing stagnation or interrupting currents which would increase pollution concentration. The impact of fills on the ecology may be realized locally in a very short period of time; other impacts on the ecology may be more gradual over a greater area and may take 20 to 50 years to reach significant proportions.

In urban areas, filling with solid waste materials may be planned and organized to serve compatible purposes of conveniently disposing of waste and carrying out planned improvements in the shoreline. The urban concentration along the Lake Erie shoreline results in the land-water interface becoming a scarce commodity. In such a case, for instance, a basin-wide urban policy calling for population concentration -- rather than permitting linear sprawl to occur along the coastline -- would certainly rely upon the creation of new land and increase of shoreline through filling and diking operations to meet more intensive development pressures. This would be particularly true in the western portion of the shallow

Lake Erie where large areas of the lake bed are within the 10-foot depth level which would be technologically feasible to fill -- and possibly economically feasible if relatively inexpensive fill materials were available.

Further study should also be given to the location and shape of shoreline land fills as a developmental policy element of coastal zone use. A series of frequent, but moderate, protrusions and indentations (inlets) along the linear distance of adjacent urban and industrial areas would provide considerably more coastal frontage than an unindented large peninsula. The main variable here would be the extra amount of land created over, say, the amount of excavation and dredging conducted to create new water bodies inland from the lake -- although when there is ample land fill materials, excavations would probably not be preferred because of their higher cost. The combined use of land fills and breakwaters provides opportunity for multiple use . For example, breakwaters could provide the foundation for constructing a peninsula to support commercial or resort uses, including small craft facilities on the inshore side and beaches on the lake side, similar to the Presque Isle recreation area at Erie, Pennsylvania. The breakwaters might also provide roadway and utility tubes to man-made islands. Artificial peninsulas or spits, perhaps coupled with excavations along narrow river mouths, can provide enlarged estuaries for fish breeding and marinas. Also, land-filled islands or peninsulas can be utilized as space for utilities (such as waste treatment plants and nuclear power plants) or industrial areas, including oil or gas production equipment or facilities for mining beneath the present lake floor.

Dredge spoil dumping sites which create land fills also raise significant policy questions with respect to the needs and uses of these land fills. For instance, will land fills made in this manner be located at sites that were planned from broad social and economic criteria or selected simply because of their close proximity to the dredging location? It is also desirable that the planning of land fills include adequate study of the impact of the new shoreline configurations on the local aquatic ecology. Another aspect deserving of study is the manner in which land fill site selection or configurations would differ between urban and rural shorelines on the basis of need for new land or for dredge spoil dumping sites.

Land fills for urban expansion are less likely found around Lake Superior because of the less-intense urban pressure and because of the deeper waters typically along the shore. However, the extensive dumping of taconite tailings at Silver Bay, Lake Superior, exemplifies the occasion of fairly large-scale filling (59,000 ton/day of taconite tailings) from disposal of mining wastes. While this operation is not directly evaluated in the context of the complicated variety of urban values, many conservation questions have been raised with respect to this filling operation, including effects of pollution on the lake and degradation of scenic beauty of the shoreline landscape. On the positive side, the mining operations on the interior are expected to last some 40 years; and in which case, the low delta-shaped tailings plateau may one day provide the major beach potential along the austere and rock-bound north shore of Lake Superior. The FWPCA has been the lead agency in a study of the Silver Bay taconite tailing operation from the environmental pollution aspects. More light may be shed on this problem when their report is released. Suffice it to say, the Silver Bay taconite filling situation gives rise to the policy question of the extent to which environmental pollution, use of the shoreline, and environmental management in relatively rural reaches is to be considered as an interrelated problem. Study of this problem by the interagency task group headed by the FWPCA and the Corps of Engineers at the Duluth Water Quality Laboratory was generated initially by an agreement between the Department of Interior and the Corps of Engineers to refer dredging and filling permit applications to DOI for review. The Corps has also initiated a policy to revalidate every 5 years such permits previously granted; and in which case, the Silver Bay dumping permit review is now being considered by the Corps in cooperation with the Department of Interior. Under consideration is the more careful study of the impact the tailings have on the lake and the extent or conditions under which dumping should be allowed to continue. The main issues of concern in the study involve the assessment of the amount of damage done by dumping tailings into the lake and the economic costs (to the public) incurred therefrom. Feasible alternative dumping sites need also to be considered and related to economic and social costs before any policy decision should be reached.

The aesthetic effects of the green water discoloration resulting from reflection from the suspended fine particles in the water is one major concern. This phenonmenon occurs in the spring and fall and is carried along the scenic shoreline 20 miles or more southwest of the dumping site.

The effect of the dump delta on the local coastal processes and ecology after 14 years of operation is another major problem. It is estimated that approximately half of the discharge tailings stay as the delta, most of which are silicates (sand-like). The other half are finer sediments which spread out on the bottom of the lake in a radius of about 15 miles from the delta to a thickness of about 2 feet near the delta perimeter to about one inch at the outer edge. While the localized effects appear to have been fairly well assessed in the study, there is virtually no information on the amount or effect of the small amount of extremely fine sediments that are likely to be spreading throughout the entire lake, either on the bottom or by circulation, or to what extent they are dissolved or will affect the bio-environment. Part of the lack of information about the wider range of impact stems from the initial study design which largely assumed the impact of the dumping was localized.

Another by-issue concerns the fact that the sediments contain a certain amount of heavy metals,possibly of sufficient toxicity to affect fish and wildlife. Again, there are virtually no facts available to determine the impact of these materials on the lake; for instance, the rate to which they dissolve into solution, settle to the bottom, or are absorbed into living organisms with harmful cumulative effects. Much more sampling needs to be carried out throughout the lake to determine the impact of the taconite dredge tailings.

In conclusion, the following priority measures in the marine sciences are recommended to achieve desirable development of the shoreline through land fill operations:

(1) It is recommended that R&D should be conducted to develop better methods to reduce the pollution effects of land fill operations, and to ameliorate the deleterious effects on the lake ecology of both small and large scale fill and diking projects.

(2) It is recommended that R&D be conducted to determine the feasibility of restoring water quality conditions and retarding the accelerated eutrophication of Lake Erie through systematically constructing temporary dikes in the shallower waters in the western lake basin to drain and remove polluted (overenriched) bottom sediments.

(3) It is recommended that R&D be conducted on the treatment of dredge spoil materials to render them to a more satisfactory land fill material, particularly including ways to separate solids from carriage water, improve bearing strength of materials,and enhance settling characteristics. R&D should also be conducted to develop efficient dredging technology to develop other lake bottom sources of fresh fill materials.

(4) It is recommended that R&D be conducted to determine the variety and amount of impact land fills have on the ecology of both the local area adjacent to the land fill and the entire lake basin, particularly including environmental changes of littoral drift and sedimentation and erosion along the shoreline, and algal accumulation. Particular attention should also be given to increasing water sampling and other environmental monitoring throughout Lake Superior to determine the impact of the taconite dumping at Silver Bay, Minnesota.

(5) It is recommended that R&D be conducted to determine the ways in which land fills may be shaped to create bays, inlets, beaches, and other configurations to provide a variety of both unique and multi-purpose uses along the shoreline.

Recommendations for priority institutional measures for achieving national and coordinated approach to land filling and other reclamation activities around the shoreline of Lake Erie and Lake Superior are as follows:

(1) It is recommended that a lake-wide reclamation policy be formulated by the Great Lakes Basin Commission for the shorelines and beds of Lake Erie and Lake Superior setting forth the basin-wide interests which should be reflected in:

a.) Filling and diking to develop new land;

b.) Filling of land for dredge spoil dumping sites; and

c.) Preservation and enhancement of ecological regimes in the lake basins.

(2) It is recommended that for the purpose of fully informing interested parties of impending filling proposals, the Corps of Engineers circulate filling permit applications to the respective regional, state, and

local planning agencies within whose jurisdiction the proposal originated. (In addition to expressing such interests as may be determined to the Corps of Engineers, local jurisdictions may control land fills by enactment of special zoning ordinances to regulate this activity. States may regulate filling operations through their legislative authority over the tide and submerged lands of the lakes, and federal agencies may petition the Chief of Engineers directly. While the regional planning authority should have the responsibility for formulating a lake-wide reclamation policy in cooperation with the above-mentioned jurisdictions, it should have no direct regulatory power to enforce the policy unless so established by basin compact agreement between the states.)

Dredging and excavation.--Dredging and excavation operations are conducted to maintain or increase the efficiency of channels and utilization of the shoreline of the coastal zone. Dredging maintains or increases the efficiency of channels (both natural and man-made) through maintaining or increasing depth. Channels may also be widened through excavation to enhance navigation or the flow of water for purposes of regulating lake levels, or dispersion and dilution of pollution.

To overcome the natural obstacles to sea-going transportation, rivers have been deepened and widened and locks constructed to enable wider and deeper draft ships to enter the Great Lakes from the ocean as well as navigate throughout the lake system. Locks and flow regulation works have been developed at the outlets of Lake Superior and Lake Erie, and the connecting channel between Lake Huron and Lake Erie (the St. Clair and Detroit Rivers) has been deepened to regulate flows to support full draft loads on ships and serve other objectives for power, lake level regulation, pollution control, and recreation.

Dredging and excavation play an important part in regulating flows and levels of the lakes as regulation works generally involve low-gated structures and enlargement of outlet rivers.[1] Conflicts in the interests served by channel dredging sometimes occurs such as the benefits derived from navigation through increasing the depth of the Detroit River versus the resulting increased cost incurred for shore property protection measures. Also, while the increased flow in the deeper channel may facilitate a greater waste-carrying load, such may be harmful to fish and wildlife resources downstream or in Lake Erie. Excavations are also done for diversion purposes such as that historically proposed for power generation in the Niagara River below the main falls. This proposal also has stirred controversy over the scenic effects of the ponding that it will cause, effects on flow regulation of water between the United States and Canada, and effects on navigation.[2] Excavation is done to cut new channels, slips, and inlets. This increases access to the water through providing increased shoreline or water reaches to interior areas. Dredging also increases the size of existing ports and harbors and can be used to construct new port areas where practical and feasible, particularly for harbors of refuge for commercial fishing, recreational boating, and smaller craft used in coastal shipping. The dredging of harbors is largely to accommodate commercial navigation, although small recreation craft are becoming a more significant benefit factor in the U.S. Army Corps of Engineers dredging projects in Lake Erie. Dredging and excavation technologies are important tools in mining sand and gravel and possibly other minerals from the lake beds.

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1 Beeton, A. M., and Rosenberg, H. B., "Studies and Research in Regulation of the Great Lakes", Proceedings of Great Lakes Water Resources Conference, the Engineering Institute of Canada and the American Society of Civil Engineers, Toronto, Canada, June 24-26. 1968, p. 311.

2 Smith, H. A., "Hydro-Electric Power Development on the Great Lakes System", Ibid., pp. 69-70.

They offer potential means for creating estuaries for developing fish and wildlife resources, and recreation and scenic values; removing nutrient-rich bottom sediments in restoring Lake Erie; and for developing holding reservoirs for run-off effluents and settling ponds. A large-scale channel excavation proposal has been made to construct a collector canal along the south shore of Lake Erie to carry treated urban wastes along the shoreline, possibly to the St. Lawrence River for deposit into the ocean, or into a neighboring watershed[1]. The latter alternative would only be feasible if water deficiency needs were significant enough to override the problem of the water's low quality.

Both excavation and bottom dredging may cause pollution problems. The disturbances of fine sediment which in themselves contain contaminants which are stirred up in both the collection and deposition of spoil material cause them to become suspended with adverse effects on the natural ecology, such as shutting out light for aquatic life and covering fish eggs and larvae. These operations also disturb the bottoms by either removing or covering the habitats important for breeding and spawning of fish and wildlife, particularly in estuarine areas. Some controversy has been raised in this regard over the dredging and excavation operations envisioned in the implementation of the master plan for development of the Port of Toledo mentioned earlier. The plan calls for the filling of a 300-plus acre shore extension for new industrial and port facilities. The fill material for the operation is to come from channel dredging and excavation of some shallower water areas nearby the fill area. The displacement of the fill will be essentially equal to the material dredged and removed from the surrounding area. Thus, the essential issues involve the extent of harmful disturbances of sediments in the

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[1] Beeton and Rosenberg, op. cit., p. 322.

process of moving material from one place to another along with the other land fill policy issues mentioned above. While the diking of the perimeter of the fill area will prohibit the adverse effect of suspended fine sediments to the surrounding area, additional R&D could be directed toward dredging and excavation devices or techniques that would limit the disturbance and scattering of sediments in these operations so as to promote the benefits of land fills while alleviating the harmful effects of dredging disturbances or land fill diffusions of polluting materials. The multi-purpose use prospects achievable through excavation and dredging are demonstrated in the example of the construction of new "U"-shaped estuaries or shoreline embayments. The modification of shoreline configuration in this manner would provide opportunities for:

(1) Increasing the length of accessible shoreline within a given linear reach of coastline, particularly if land fills were used on the seaward side in conjunction with the project.

(2) Serving water and access inland up to several miles, thus relieving pressure for adjacent coastal frontage location for certain utilities and urban and industrial uses requiring large amounts of fresh water.

(3) Providing a natural buffer separation between recreation and other urban and industrial uses.

(4) Achieving additional benefit of decreased rights-of-way for utility easements by being closer to user markets (which could be accrued to the estuary excavation project costs).

There appear to be three main areas in which dredging and excavation technologies could be improved: (1) the development of conventional mechanical or hydraulic dredging devices that have greater depth and volume capacity, (2) the perfection of dredging and excavating techniques that limit the amount of sediment disturbance, and (3) the exploration of utilizing nuclear excavation technology, particularly in connection with developing limited-size harbors of refuge around the less-populated shoreline of Lake Superior.[1]

In conclusion, the following measures are recommended for improving dredging and excavation technologies utilized in the coastal zone of Lakes Erie and Superior:

(1) It is recommended that R&D be considered for developing techniques to reduce the disturbance of sediments in dredging and excavation practices.

(2) It is recommended that R&D be conducted to develop deeper and larger capacity dredging and excavation technologies, particularly with regard to developing an efficient dredging system for dredging large areas of Lake Erie in a restoration program.

(3) It is recommended that R&D be conducted on the development of low-cost nuclear excavation technologies, including the predictability of blast results, improvement of safety measures, and the study and reduction of radiation effects (if any) on fish and wildlife.

The following institutional measures are recommended with respect to dredging and excavation technologies:

(1) It is recommended that the cost-effectiveness of dredging limited segments of the bottom of Lake Erie in a program of restoration be evaluated through an engineering feasibility study.

(2) It is recommended that the dredging and excavation operations be included within the lake-wide reclamation policy described in the section on "land fills."

<u>Protection against shoreline erosion and sedimentation</u>.--The major causes of shoreline erosion and deposition of sediments are: (1) natural current and wave action, (2) man-made modifications of the shoreline configuration or connecting lake

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1 Although the cost-benefit ratio for excavating small harbors with nuclear explosives does not appear very favorable at this stage of the technology, it is possible that this will improve with further advances of the technology or widespread application which would bring economies of scale.

channels, (3) increased run-off of silt and waste-laden waters from agricultural, urban, and industrial activities, (4) gouging by lake ice, (5) excessive lake levels and run-off due to extended periods of above-normal rainfall, and (6) wakes and waves generated by large vessels as well as smaller water craft. Erosion and sedimentation protection measures include construction of protection structures placed offshore, such as breakwaters, to modify shore currents; and structures placed along the shoreline and channel banks, such as rip-rap, steel pilings, and groins. Flood plain management measures, such as restricting development in areas subject to inundation is also an alternative to the necessity of constructing flood protection works.[1] High lake levels have the greatest effect on shoreline erosion, particularly beaches and flooding of lowland areas adjacent to the shoreline.[2] Extreme low levels may also cause increased siltation in channels and harbors due to the slower circulation and settling of suspended solid materials emitted into rivers and the lakes.

Conflicts arise with respect to the benefits achieved through regulating the flows and levels. For instance, while maintaining lower levels for the benefit of flood protection, navigation and power uses of the lake and connecting channels may be inhibited. Even within one particular use, such as recreation, conflicts may arise: higher lake levels may enhance boating activity and marine operation, while lower levels may enhance beach use. Army Corps of Engineers in cooperation with the International Joint Commission is conducting a study of shoreline protection needs due to periodic excessive lake levels. It is anticipated that information collected by the Corps and similar Canadian surveys will help determine the extent to which shore protection needs may be met through regulation of lake levels or through construction of protective works.

In conclusion, the following measures are recommended for enhancing shoreline erosion protection technologies:

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[1] Beeton and Rosenberg, op. cit., pp. 317-318.

[2] Kirshner, Louis D., "Effects of Diversions on the Great Lakes," Proceedings of Great Lakes Water Resources Conference, op. cit., pp. 297-298.

(1) It is recommended that R&D efforts be strengthened toward determining the effects of lake and river flows and levels, wave action, ice, wind and rain on the shoreline.

(2) It is recommended that R&D efforts be strengthened toward developing protective or other coastal engineering structures to enhance the control of lake levels and flows and minimize the adverse effects of the forces of erosion and deposition.

(3) It is recommended that R&D be conducted to develop techniques and coastal engineering structures that will enhance multiple use of the shoreline as well as serve their primary objectives of protection and regulation, such as the use of breakwaters to divert offshore currents along the shore to flush waters adjacent to recreation beaches.

In addition, the following institutional measures are recommended to enhance shoreline protection:

(1) It is recommended that the implications of the IJC water level study with respect to shoreline protection be included in the formulation of a lake-wide reclamation policy for Lake Erie and Lake Superior.

(2) It is recommended that flood plain management be explored further as an alternative to shore protection and flood control measures, and that the Corps of Engineers effort in this area be strengthened.

Port and harbor development.--Port and harbor development in Lake Erie and Lake Superior largely involves the expansion of existing facilities to handle increased transshipment demands, such as the programs presently under way at Toledo and Cleveland and, to a lesser extent, Erie and Duluth-Superior. Some harbors, once the scene of great port activity (e.g., Buffalo and Erie), have experienced considerable decrease in shipping Rather than attempt to redevelop their harbors as port facilities, these cities are working toward rehabilitating their waterfronts to other productive urban and recreational uses, such as the new civic center developments of Detroit and Duluth and the high-rise housing and recreation project under way at Buffalo. Completing the St. Lawrence Seaway and connecting channel projects have given impetus to port development on the Great Lakes to accommodate deep draft traffic,[1] and have caused the development of such facilities as the ore-loading facility at Superior and the competitive efforts of Toledo and Cleveland in their development of transshipment facilities.

Changes are still being made in the Great Lakes and the St. Lawrence Seaway locks and channels and in Great Lakes shipping trends that will have a significant impact on port and harbor development in Lake Erie and Lake Superior, and other Great Lakes ports. Both the increase in hinterland trade and trends in bulk cargo carriers will have some effect on the future development of port and harbor facilities. Until last year, the largest ship that could operate between Lake Erie and Lake Superior was limited to 730 feet in length and to 75 feet in beam by the MacArthur Lock in the Sault Ste. Marie between Lake Superior and Lake Huron. Its draft restriction (25 feet, 5 inches at mean low water) is not caused by locks, but by channel depths in the St. Marys and the Detroit-St. Clair Rivers. At high water, a ship using these channels can draw an additional two feet, bring the draft to 27 feet, 5 inches. Present maximum carrying capacities of lake vessels when loaded to this draft is estimated at about 28,000 tons.[2] When the new Poe Lock in the Sault Ste. Marie was completed in 1968, it opened routes between Lakes Erie, Huron, Michigan, and Superior to ships 1,000 feet long, 105 feet wide, and having cargo-carrying capacities up to 44,000 dead weight tons. Two such ships are being constructed at Erie and Lorain. Since draft limitations remain unchanged in the Welland Canal between Lake Erie and Lake Ontario and in the St. Lawrence Seaway, these new ore carriers with greater drafts will be able to navigate only throughout the Great Lakes system.

TABLE 2

THE COMPARATIVE DIMENSION OF THE EXISTING MACARTHUR LOCK AND THE NEW POE LOCK[3]

MacArthur Lock		New Poe Lock	
Year Constructed	1943	Conpletion date	1968
Length	800 feet	Length	1,200 feet
Width	80 feet	Width	110 feet
Depth over sills	31 feet	Depth over sills	31 feet

[1]Great Lakes Water Resources Conference, op. cit., p. 25

[2]Erie Waterfront Development Plan, op. cit., pp. 60, 61.

[3]Ibid..

Present locks and channels on the Welland Canal have the same restrictions as those on the St. Lawrence Seaway from Montreal to Lake Ontario. Although the largest ships that can sail from Lake Erie to the Atlantic are 730 feet long, 75 feet wide, with a draft of 26 feet and a mast height of 117 feet above water, ships over 715 feet long with beams over 72 feet are still subject to special restrictions when using the Seaway.[1] The maximum draft of a ship negotiating the Seaway between Montreal and Lake Erie is limited by the present 27-foot channel depths rather than by locks, which have 30 or more feet of water over the sills. A proposed All-American canal between Lake Erie and Lake Ontario would have locks with the following dimensions: Length - 1,200 feet, Breadth - 110 feet, and Depth over sills - 32 to 35 feet.

Increasing the lock dimensions will permit the transit of longer and wider ships from the Great Lakes to the ocean. However, there will still be a draft restriction of 26 feet until the Seaway channels are deepened. It is conceivable that in the futur the channel would be deepened to permit the new lake bulk carriers, otherwise captive in the lakes, access to the Labrador ore fields and the Atlantic trade routes.

The new 44,000 dead weight ton vessels appear to be setting a new trend in lake freighters to a smaller number of larger and faster ships[2] which may, to a great extent, replace the traditional fleet of 350 lake carriers which range from 10-15,000 dw A considerable number of the latter vessels will continue to be needed to provide short-haul service of other cargo, such as aggregate, or salt, to interior locations accessible by present harbor and channel systems which will not be feasible to develop for accommodating the larger vessels. The new vessels will require smaller crew ratios and will be equipped with self-unloaders. The latter may lessen the necessity of the expensively operated and maintained large-armed unloaders and, at the same time, require more open space for quickly unloading large amounts of ore and other bulk materials. In order to operate efficiently with self-unloading capability and large cargo capacity, these new bulk carriers will most likely frequent/ a few major port locations needing considerable increase

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[1] Ibid..

[2] Great Lakes Water Resources Conference, op. cit., pp. 24-25.

in open storage areas and increased depth maneuvering and turn around space in the harbor. Increase in use of containerized cargo shipping will similarly require more open space storage area next to berthing facilities. The efficiencies of containerized shipping are also such that larger, faster and more expensive ships prefer to stop at a single port for quick loading and unloading, in which case, Duluth, Toledo, and Cleveland may evolve as major container transshipment terminals with smaller ports of the size of Erie serviced by collector "barges" carrying containers to either Toledo or Cleveland. This system is already becoming operational on Atlantic Coast ports.

New trends in Great Lakes shipping are likely to lead to the development of certain centralized major/transshipment terminals requiring deepening and widening of channel and berthing facilities and larger open storage areas as well as increased load lifting equipment, such as "Big Lucas" at Toledo/or the 150-ton capacity crane at Cleveland, for certain processed or fabricated cargoes. These improvements will require both dredging/and excavations and land fills. Since most of the harbors are either closely hemmed in by adjacent urban development such as either Toledo or Cleveland or physical barriers such as the bluffs immediately overlooking the port of Erie, the new open storage area needs will, for the most part, be met by creating new land fills.

The possibility of eventual use of nuclear-powered vessels will require study of the special port facilities necessary to service nuclear-powered ships.[1] Such a study would likely entail new locations for port development, in which case, nuclear excavation may also be considered along with conventional excavation technology.

In addition to the development of port facilities for commercial shipping operations is the development of a system of small craft harbors of refuge, particularly in Lake Superior. These harbors could also serve as support for increasing recreation use of Lake Superior in supplement to other marine development projects, such as are under way in the Upper Great Lakes Regional Commission.

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[1] Senate Joint Resolution 167-Proposed Advisory Commission on Nuclear Port Development (Magnuson), Congressional Record - Senate, May 2, 1968, p. S4817.

It is essential that marine terminal development be integrated with the comprehensive planning and developmental activities of state and local governments (including metropolitan area organizations), particularly with respect to the transportation elements of these programs. However, the dynamic pace of innovation in ship construction and cargo handling technology and the increasingly keen competition for domestic and international/ transshipment trade is often beyond the capability of local, city, and county governments to accommodate in their port facility modernization or expansion plans. A major problem is the competition between urban and state programs of various kinds for tax revenues plus the often sluggish administrative processes of local government.

It is recognized that the establishment or perpetuation of another autonomous layer of government such as a port authority is, in some ways, counter to prevailin efforts to streamline the extreme complexity of agencies, jurisdictions, and author ties into a more rational and orderly planning and decision-making process in government. In the face of the rapid pace of technological innovation in the shipping industry, it appears that—at least in the short run--autonomous port authorities along Lake Erie have been better able to initiate and carry out port development programs. As the problems of intergovernmental coordination increase, it is also highly likely that in the not too distant future an overall institutional coordination effort may be required of drastic proportions to enable government to carry out its function. At that time, the role of autonomous port authorities will undoubtedly be re-evaluated.

Last year, the port authority of Cleveland moved out from under city governme and developed a port development promotion program and submitted to the electorate a bond program which was approved. Similarly, the Port of Toledo is an autonomous agency, and is working closely with local and regional government authorities.

The Toledo-Lucas County Port Authority has developed a master plan for port development which is being coordinated with the comprehensive planning program of the Toledo Metropolitan Area Council of Governments (COG). An application for a federal comprehensive urban planning grant (HUD-701) has been initiated to complet the plan and development program for the Port of Toledo as a component element of the COG's Comprehensive Land Use Transportation Study. The work program outlined in the application is a fine example of the manner of study through which port planning may be related to a regional planning program:

- o Analysis of waterfront usage on the Maumee and Ottawa Rivers and Maumee B
- o Analysis of shipping to and from the Port of Toledo
- o Analysis of port-oriented employment and travel
- o Analysis of locational aspects of port-oriented development
- o Analysis of technological trends in port development
- o Preparation of waterfront development plan
- o Hydrographic and waterflow studies

The question may be raised as to what might be the role of the Marine Science Council or Great Lakes Panel in reviewing such planning applications with respect to national policy on marine science and technology and the increasing use of the coastal zone?

The recent Erie Water Front Development Plan recommends a fully autonomous Erie Port Authority to be established by the Commonwealth of Pennsylvania with powers to:[1]

(1) Exercise the right of eminent domain over all territory within its jurisdiction.

(2) Control access to, and navigation in, harbor water.

(3) Insure non-discriminatory access for all persons and modes of transportation to waterfront installations.

(4) Enforcing zoning laws in water and shorefront properties and introduce additional by-laws or regulations within the framework of state and federal legislation necessary to the control and protection of the port.

(5) Levy port, pilotage, or demurrage fees.

Besides the need for port and harbor improvements to be related to a lakewide reclamation policy, these improvements should be related or coordinated with the overall development of the urban waterfronts within which they are being developed.

[1] Erie Waterfront Development Plan, op. cit., p. 72.

This is in order to integrate both the port and harbor activity within the activity environment of the city with respect to enhancing the recreation or other water-oriented commercial opportunities in and around the harbor; and to plan, develop, and maintain an effective transportation system linking other transport modes from the port hinterland and along the coastal zone. It is usually incumbent upon such autonomous port agencies to coordinate with city and county and regional governments having responsibility for planning and decision-relating to the overall growth of the city or area. To make such coordination effective, the local agencies need to respond to early development commitments in ports and harbors even though some of these projects may be long range in their completion. This is particularly important with respect to comprehensive transportation planning programs where certain decisions may have to be made with respect to marine terminal development in the absence of clearly defined development policies for other transportation mod

The following measures are recommended for facilitating port and harbor development in the coastal zones of Lake Erie and Lake Superior:

(1) It is recommended that engineering and systems studies be conducted by the Department of Transportation on efficient port and harbor design, particularly including:

(a) Patterns of ship and small craft movement.

(b) Faster and larger capacity cargo transfer equipment and methods.

(c) Efficient storage patterns.

(d) Equipment and techniques for rapid intermodal transfer of cargo within marine terminals.

(e) Offshore cargo transfer facilities for bulk cargo tankers and freighters using different transport modes.

(f) Development of a coastal cargo collection system for facilitating usefulness of large bulk and container vessels in centrally located marine terminals.

(2) It is recommended that study be given by the Corps of Engineers to the development of a harbor of refuge plan for Lake Erie and Lake Superior, including:

(a) Land use, marine ecology, and geological studies to determine optimum location for creating new harbors of refuge.

(b) Studies to determine the design characteristics of harbors of refuge to optimize safety and related commercial, recreation, or fish and wildlife potentials available through multipurpose development.

(3) It is recommended that the Marine Sciences Council coordinate the Departments of Interior, Transportation, Housing and Urban Development, and the Corps of Engineers in the conduct of R&D toward developing port and harbor construction standards and techniques that will accommodate multipurpose use of harbor areas, including navigation aids, urban uses, recreation, and fish and wildlife.

The following institutional measures are recommended for port and harbor development:

(1) It is recommended that state enabling actions for autonomous port agency creation and federal assistance programs in port and harbor development requir the coordination of port and harbor planning development with comprehensive transportation and urban planning activities within their respective jurisdictions.

(2) It is recommended that proposals for land fill and excavation projects in port and harbor development be related to the lakewide reclamation policy.

(3) It is recommended that the Department of Transportation be the lead agency for providing technical and financial assistance to state and local governmental agencies in carrying out R&D related to the above recommendations. It is also recommended that state and local involvement in these R&D efforts be encouraged.

Social and Economic Uses of the Coastal Zone

Transportation.--The shoreline of the coastal zone in the Great Lakes is where land, air, and sea transport modes meet to form an integrated system. Technology associated with the development of an integrated transportation system in the coastal zone will frequently involve both modifications of the shoreline configuration and the effective use of open space above the coastal zone as well as the development of new transport vehicles and support facilities as terminals, cargo, and passenger handling equipment, and storage and marshalling areas. The Great Lakes support a vital transportation artery for commerce between the midwestern states of the United States and several provinces of Canada -- and with the building of the St. Lawrence Seaway provide sea transport access to the East Coast of North America and other world ports. The location and capacity of the connecting rail, highway, and air transportation systems, particularly those stemming from Lake Erie, also have been major forces in shaping the economic growth of the region. The reliance on inexpensive, water-borne transportation has influenced the location of basic industry in port and shoreline areas to the point where about one-half of the Nation's steel manufacturing capacity is presently located directly in Great Lakes ports, and which further serves large sections of the steel industry located in the hinterland (e.g., Pittsburgh, Youngstown, and Wheeling). As transportation systems expand to link Great Lakes ports with non-coastal regions, two things are happening: First, there is a decrease in pressure for port-located industrial and commercial land as efficient transportation enables industrial growth to centralize into hinterland marketing areas. Hinterland communities are effectively competing for the relocation of older industries as well as new growth industries. Second, trends in shipping technology and the increase of urban and industrial growth throughout the region is creating greater demands for efficient and larger capacity transshipment facilities in ports, such as Cleveland and Toledo, which have initiated ambitious port development programs.

As mentioned earlier, some ports have actually decreased in overall transshipment activity due to a combination of causes such as intense competition between ports in the form of provision of better facilities or more favorable transshipment and storage rates, better hinterland access, and a greater growth rate in the hinterland. Competition from rail and truck transport has also cut into water-borne commerce. For instance, much of the hinterland-oriented trade, once shipped through the Port of Buffalo, has decreased for these reasons. While this is true for transshipment cargos, Buffalo maintains a stable tonnage of raw materials -- which now makes up 95% of the total tonnage entering the port -- destined for the steel or grain processing mills of the Buffalo area where it is consumed or processed and shipped as finished products by means of various transport modes.[1] Rail and water access to the Port of Erie is adequate; however, highway access is poor in spite of the growth of trucking as a mode of freight transportation in recent years. The completion of Interstate Highway 79 between Erie and Pittsburgh and the construction of port-access roads will correct much of this deficiency.[2] Erie is also a case where physical constraints, such as the bluffs immediately behind the port area, inhibit linkage between land and sea transportation modes. The potential for the extended development of the Port of Cleveland is constrained by a lack of coordinated rail facilities for handling north-south traffic into and out of the Cleveland and hinterland area. The

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1 Policies and Plans for Transportation in New York State, Office of Planning and Development, New York State Department of Transportation, Albany, New York, September 1968, p. 31.

2 Port of Erie Waterfront Development Plan, op. cit., p. 60.

existing hinterland development has been principally determined by highways and trucking services.[1]

The annual closing of the Great Lakes shipping season for 3 1/2 to 4 months is another shortcoming of commercial navigation on the Great Lakes. This annual closing of the shipping season caused by the winter freezing of the lakes creates great economic loss in immobilization of a fleet of expensive ships and docks, seasonal appointment of crews and longshoremen, cost of stockpiling of materials, cost of re-routing to other means of transport. As the volume of commerce increases, reduction of the non-shipping period becomes increasingly important and justifiable.[2] Increasing the rates of flow in order to inhibit the formation of ice in shipping channels and canals is one means of lengthening the season. Other measures under consideration include the strengthening of Great Lakes cargo carriers with Alexbow modifications in order to enable operation under ice conditions a few weeks later into the season and perhaps a few weeks earlier into the navigation season. The Alexbow is a revolutionary marine ice plow that is attached to the bow of a ship. The Alexbow is thrust under the ice and breaks it by lifting rather than by applying downward force from the weight of a conventional icebreaker or ship such as the U.S. Coast Guard cutter Ojibwa.[3] The Coast Guard has leased the Canadian-invented Alexbow ice plow to tests its efficiency. The Ojibwa is a 110-foot long harbor tug equipped with reinforced hull capable of breaking through 40-inch ice. Larger icebreakers of the Coast Guard fleet have been tested in the

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1 Sweet, David C., and Maggied, Harold S. "Analysis of a Port's Hinterlands", Battelle Technical Review, October 1967, p. 5.

2 Mackey, W. R., "Commercial Navigation on the Great Lakes", Proceedings of Great Lakes Water Resources Conference, June 1968, Toronto, Canada, p. 111.

3 Gleasner, Dianna C., "A Ship For All Seasons", Boating, January 1969, pp. 73-75.

Great Lakes with only moderate success. The use of air bubbles to maintain circulation in a shipping lane or channel is a method of preventing ice formation which has been used in marinas but has not been used in larger ports or channels. Power plants, or their heated outflows, could be placed offshore in strategic locations to facilitate more effective use of thermal effluents in maintaining lanes or channels (such as a small craft port of Dunkirk, New York).

The maintenance of flow levels is important for navigation in all seasons in order to insure that shipping can operate economically. It is essential that ships operating in the Great Lakes be able to load their full draft and not be penalized by being forced to carry reduced cargo due to inadequate flow levels, particularly in the river channels.[1]

> When it is realized that an inch of draft represents 125 tons of cargo on a large freighter, any decided lowering of the water level can cause severe losses in quantity of cargo moved and in the unit-cost of cargo movements. It is, therefore, necessary that a stable water level be maintained on the lakes and that, if necessary, additional water control and storage capacity would, of course, not only be available for navigation but would also be available for other uses -- namely, hydroelectric power generation, industrial and municipal use, and recreation.
>
> The safety of navigation is dependent on adequate width and depth and interconnecting channels and in uniformity of flow. The provision of deeper or wider channels between lakes would result in increasing the rate of flow and, thereby, further lowering the water level in the lake above. The answer would seem to be in the provision of more control of water levels in conjunction with the channel improvements, thereby providing greater uniformity of flow and stable water levels, thus reducing the need for further deepening of the 102 ports on the Great Lakes. Although the cost of such work is a major consideration, it should be compared against the value of the regulated levels to the economic growth of the Great Lakes basin.

Shipping in the Great Lakes and the development of ports and harbors are closely related to the operation of other transport modes. Furthermore, the

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[1] Mackay, <u>op. cit.</u>, pp. 109-111.

design of an integrated transportation system should be accomplished with the land use consequences of alternative courses of action clearly in mind.[1] Many more miles of roads and highways will need to be built to accommodate the urban growth of the coastal zone of Lake Erie. With limited land and funds for highway development, new technologies will be needed to increase the transport capacity of existing urban streets and highways.[2]

The construction of completely new high-speed rapid transit systems can be a major factor in distributing and shaping urban growth patterns along the coastline, as well as relieving the pressure from highway congestion and expansion needs.[3] Better linkages between modes will also help relieve highway congestion. For instance, Cleveland has recently completed a rapid transit link from Hopkins Airport to the downtown district. As the Great Lakes Megalopolis continues to develop, the use of fast hydrofoil or hovercraft may become feasible for ferrying people across and along the shores of the lakes, particularly in the western portion of the shores of Lake Erie. This kind of vehicle would be especially versatile for transversing ice when too thin to support an automobile or when interrupted by a channel made by an icebreaker.

Locations of freeways along the shoreline provide two control measures for shoreline use.

The location of freeway interchange facilities is an access

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1 Systems Considerations for Urban Freeways, Institute of Traffic Engineers, Washington, D. C., October 1967, p. 43.

2 Turner, Francis C., "The Highway and the City", Petroleum Today, Summer 1967, pp. 1-4.

3 "A Transit Line Gets on Track", Business Week, September 1968, pp. 162-63, 166-68.

control tool, and the use of excess condemnation to acquire the narrow strips of land between shoreline routes and the water's edge is a valuable tool in preserving scenic qualities of the freeway and the shorelines. The freeway located immediately adjacent to the shoreline while offering good scenic qualities for travelers also rather effectively cuts off the shoreline from the hinterland which, depending on the ultimate use envisioned for such lands and shoreline, may or may not be a desirable condition. Offshore locations for highway development via causeways or dikes also look more inviting as the shoreline becomes more densely developed.

Containerization technology is rapidly becoming a major factor in the movement of cargo along the coastal zone and through ports to hinterland market areas. Many of the principles learned from bulk cargo transportation, such as grain, ore, and petroleum in the Great Lakes, have been applied to evolving modern container shipping, including development of containers and the machinery for loading, unloading, and transferring to other transport modes, and larger and faster carriers. Railroads are already adapting to larger bulk and container trains, such as operating unit trains. Advances in bulk truck carrier technology[1] will also create the need for better intermodal exchange between trucking, railroads, and ships at marine terminals on Great Lakes ports. One of the basic facts of transportation is that a vehicle -- whether it is a ship, an airplane, a truck, a barge, or a train -- earns revenue only when it is carrying cargo. Efficient turn-around time and intermodal transfer has become strategically important in transportation system planning.

The development of 1,000-foot long and 105-foot wide lake freighters made

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[1] "Tank Truckers Thrive on Diversified Fare", Business Week, December 7, 1968, pp. 84-88.

possible by the completion of the Poe Lock at Sault Ste. Marine may also be designed to carry containers. While these large freighters will be confined to the upper lakes (as discussed in the section on Modifications of the Coastal Zone), a new "breed" of ship is being designed by Canadian naval architects which has the dimensions and cargo capacity of a lake freighter and the seaworthiness and strength to navigate in the open ocean. These new ships can operate within or into the Great Lakes during the lake navigation season and then operate along the Atlantic Coast or other international routes during the winter. Cargo can be moved by these ships at the cost of 1 mill per ton mile as compared to a rate of 2 mills for smaller ocean vessels; at these rates, cargoes can be moved from lake ports to Europe as cheaply as a train can move cargo from the mid-west to the seaboard.[1]

Container shipping may be viewed as a key factor in designing marine terminals along the shoreline of Lake Erie and possibly in the future in Lake Superior. If they are to operate at maximum efficiency, container-ship terminals must be designed differently from the conventional roofed piers used by break-bulk ships. The best kind of facility for handling container ships is the quay wharf with powerful shoreside cranes. The wide aprons are needed to provide easy access to the side of a ship for tractors moving containers. Moreover, a container-ship terminal needs ample room for assembling containers coming from overseas for delivery inland and vice versa. Studies have shown that generally 12 to 15 acres of assembly area is the minimum requirement for each ship berth. Such an area can hold about 1,000 containers, half of which are inbound and half outbound.[2] While container ship terminals should be efficiently linked to major highway and

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1 Mackay, <u>op. cit</u>., p. 108.

2 "Cargo-Handling", <u>Scientific American</u>, October 1968, p. 85.

and rail trunk lines, they present a problem when located in the hearts of major cities already clogged with vehicles. "A port for container ships in the heart of the city adds to the traffic problems and to the cost of transporting goods out of the port."[1] Other factors affect the overall efficiency of an integrated transportation system, such as the extent to which the highway and rail networks service the hinterland. This is why a comprehensive approach to transportation planning is needed in order to best judge the extent to which one particular mode (e.g., marine terminals) may be developed to achieve a balanced system. In this instance, investing in port development to handle more cargo than the hinterland transport systems can accommodate, or than can be produced or consumed within the hinterland is "overinvesting". Alternatives would be to phase port development with development schedules of other transport networks or, in the event that such other improvements are not to be made in the foreseeable future, to make port improvement objectives more in scale with the overall transportation system. On the other hand, as discussed in an earlier section, the improvement of port facilities to accommodate new transport technology may still demand large investments ahead of what would be an ideally scheduled and phased development of an integrated transportation system.

Because of the combined factors of the land and air space needed for airports and the increasing difficulty in meeting these requirements on land around the urbanized areas of the coastal zone, several coastal metropolitan areas have proposed airport expansion or new airport construction offshore of their coastlines. Major offshore airport projects have been proposed for Los Angeles, San Francisco, Chicago, and more recently, Cleveland. The Chicago proposal was developed by

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[1] Our Nation and the Sea: A Plan for National Action, Commission on Marine Science, Engineering, and Resources, Washington, D.C., January 1969, p. 66

local authorities and has received preliminary approval by the FAA.[1] It calls for diking and draining a circular area 4 miles in diameter and 35-55 feet deep. Development is expected to take up to 8 years to complete at a cost of $432 million. (Construction could be completed more rapidly at higher costs.) The Cleveland jetport proposal, developed by NASA, involves filling 1,050 acres of land in waters 20-30 feet deep a mile offshore of the city for a terminal and two 2-mile long runways. The project is expected to take 10 years to complete at a cost of $1.185 billion (for the initial phase). The advantages offered by offshore locations for new large airport facilities are exemplified in the Cleveland proposal:[2]

- Unlimited room for expansion;
- No land removed from the tax rolls;
- No obstructions in the flight path;
- Little residential noise problem;
- Easy access to the central city and a ring of satellite airports;
- Simultaneous take-offs and landings with a minimum amount of taxiing;
- Centrally located in region of high population and industrial density.

NASA's involvement in the proposal development stems from a request by President Johnson that federal agencies assist local communities in solving their problems. The concept of an offshore regional airport facility had been included in an earlier transportation element of the Cleveland General Plan recognizing the increase of intercoastal air-taxi service reaching airline proportions and the need for another airport facility beyond Hopkins and Burke Airports to handle

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1 "Chicago Plans Airport in the Lake", American Aviation, July 22, 1968, pp. 39-43.

2 Bloomfield, Douglas, "$1 Billion Jetport in Lake: NASA Plan is Result of Two-Year Secret Study", The Plain Dealer, February 13, 1969 (Cleveland, Ohio), pp. 1,6

the growing commuter load. NASA conducted the jetport study inhouse over a two-year period. The study was done quietly in order to avoid arousing consternation over specific engineering and ecological relationships before the "concept" had a chance to be fully expressed. For instance, the facility was located one mile offshore of Cleveland because it was felt this was the closest desirable distance due to noise and traffic (air and water) problems. However, now that the concept has been developed, it requires review by agencies, organizations, and citizens in the regions which have an interest in or will be affected by the proposed facility. Presently, the (Ohio) Governor's office has initiated an effort to organize the various regional airport proposals that have been developed for the region to develop for Ohio a policy position on these proposals. Presently, the jet-port proposal is being reviewed by other agencies concerned in the area, such as the local regional transportation planning agency, the port authority, and other state and local agencies. Additionally, Kent State University under the auspices of the FAA is conducting preliminary air traffic feasibility studies to determine the requirements for air traffic patterns, including noise abatement requirements now and into the future. The Cleveland Seven-County Transportation Study presently being conducted is scheduled for publication this summer. The allotted time for the study will be inadequate to fully assess the impact of the new jetport proposal, such as the adjustment that may be required in new shoreline highway routes and capacities and the feasibility of tying into the rapid transit system as was done for Hopkins Airport.

With respect to the relationship of the jetport in marine transportation, some aspects of the air and sea transport mode interface are incompatible. The primary reasons for this lie in the problems with air space obstructions in traffic lanes and docking areas of ships. Furthermore, the ship-to-aircraft or aircraft-to-ship flow of people and cargo is not presently significant. However, the air cargo needs of future air carriers is increasing and along with it, the need for air carrier interface with truck and rail modes -- particularly as containerization becmmes more feasible through large jumbo-jet aircraft.

Developments in air transportation technology and the increasing amount of passengers and cargo being carried by aircraft have placed new and greater emphasis on integrating air terminals into transportation systems.[1] "Containerization is rapidly becoming a major factor in the movement of cargo by air. Indeed, the economic feasibility of the huge air freighters scheduled to go into operation within the next five years is predicated on the prospect that containerized cargo will be loaded and unloaded by highly automatic mechanical devices. Underlying these recent and prospective developments is a change in attitude toward air freight. Until recently, most air freight was of a priority nature; the plane's speed was more important to the shipper than the freight charge. Now other reasons prevail. Air transportation enables many wholesalers to reduce inventories of stock on hand, because they can get more stock quickly by air freight. New markets have been opened or extended by air freight." For instance, "Lockheed believes its L-500 could reduce the cost of door-to-door shipment to about 10 cents per ton-mile, making it quite competitive with surface transportation for types of cargo not now sent by air because of the cost." This would increase the cargo requirement for the jetport and, therefore, the question arises with regard to the assumption that Hopkins be turned into the cargo-oriented airport for the region. The inadequacies of Hopkins Airport to handle jumbo-jet cargo carriers will be the same in the future as it is now.

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[1] "Cargo-Handling", op. cit., pp. 87-88.

Another problem in integrating large new airport facilities into the comprehensive planning for a regional transportation system and one which is similar to the need for rapid innovation in port facilities mentioned earlier in this section is that the construction of major airport facilities requires about 10 years lead time:[1]

> Airports being finished today were designed 10 years ago for an earlier generation of jets, with the idea that the supersonic transport would come sometime in the mid-1970's, allowing time to lengthen runways and build larger flight stations. Today's airports are in trouble because the technology of aircraft engine makers has outstripped the foresight of airport planners.

In addition to the possible need for increased air cargo handling space, the demand for industrial land of the kind that prefers to locate near or adjacent to air cargo terminals may create pressure for additional expansion of land fills. With respect to the land fills for the jetport proposal, dredge spoils from the Cuyahoga River reportedly are not suitable for fill material due to the nature of the fine sediments which wash down the river.[2] Consequently, developers will probably turn to the lake bottom for a source of dredge materials for filling the airport facility. Such a large-scale dredging operation needs to guard against pollution effects from disturbance of bottom sediments. Quite importantly, it offers multiple-use opportunity for offshore development which improves the benefit-cost ratio of such a high-cost fill project. An offshore storm-sewer holding reservoir had been proposed in conjunction with the earlier offshore airport facility proposal involving a trapezoidal-shaped dike area about 3,000 feet into the lake and one mile long easterly of Cleveland's downtown area. The proposal is now also being studied by the FWPCA. If the fill material were satis-

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1 "Mammoths of the Air Worry the Airports", Business Week, December 14, 1968, p.60.

2 It would also require about 40 years of river dredging at the present annual rate of dredging.

factory, dredging from this area would provide both a convenient source and increase the holding capacity for the storm drainage reservoir.

The Cleveland Jetport Proposal raises the many implications of shoreline modification and for land use, transportation, fish and wildlife, and coastal processes questions involved with the use of offshore waters and bottom areas. While the jetport facility is yet an expression of concept, certain decision-making wheels have already been set into action. For example, the Governor of Ohio has already asked for legislation to expand the state Port Authority Act to enable the Cleveland Cuyahoga County Port Authority to expand its authority to include airports, bridges, buildings, and transit systems. The City of Cleveland, while agreeing with the principle of the concept, is questioning the necessity of such new authority inasmuch as the city now operates the Burke and Hopkins Airports. The City of Cleveland is transferring to the Cleveland Cuyahoga County Port Authority the waterfront areas of the city to develop into public port facilities, especially for intermodal transfer. This is to augment docking facilities located along the Cuyahoga River which are virtually all owned by private industry and serve, in a sense, as a backdoor service route to industries located along the Cuyahoga River.

The offshore location of the jetport, in the case of Cleveland, will require a grant or lease from the State of Ohio for the submerged bottom lands. In the event the state Port Authority Act is expanded to administer the jetport, the requirement that a comprehensive development plan be formulated to support the state grant or lease application for the lake bottom area, as was the case of Toledo port development program,should be maintained. Also, the notion of a comprehensive development plan indicating the land use, environmental impact, transportation implications, and coordination requirements should be required in support of all large-scale projects in offshore waters. Other local agencies are questioning the impact of the large land fill for interrupting the easterly flow of currents along the shoreline, which may result in increased sedimentation west of Cleveland in erosion of the east side. Ideas such as moving the facility further out into the lake and tunneling the access road have been suggested for consideration in this regard. Such modifications in the present plan may cost more money but, at the same time, may introduce a new set of benefits.

As of March 1969, the Corps of Engineers has not yet been contacted with respect to acquiring the development permit required. The Corps of Engineers, however, has indicated that the applicant -- whether it be a local port authority, the City of Cleveland, or the State of Ohio -- will need to provide information to assess the impact of the jetport proposal on navigation, fish and wildlife, and shore processes in order that a rational decision can be made by the Corps. Other agencies will also be involved through the Corps of Engineers' permit review procedure, such as the FWPCA, the Bureau of Commercial Fisheries, and the Department of Health, Education, and Welfare. Preliminary reactions on the Corps' part have indicated its expression to maintain a navigation approach to the Cleveland Harbor in terms of ships crossing the glide path of the airport. The Bureau of Commercial Fisheries, for example, intends to review the impact on fish and wildlife in response to its being notified pursuant to the Corps of Engineers' permit review procedure. Additionally, the Bureau may be involved in doing an impact study on a cost-reimbursable basis from the agency authorized to conduct the planning and engineering studies on the airport facility. In this instance, a portion of the study monies would be allocated by the lead study agency to the Bureau of Commercial Fisheries to evaluate the impact on fish and wildlife and develop ways to protect the resource, minimize losses, and also to assure that wildlife hazards are minimized to air traffic -- such as problems that might arise from migratory waterfowl during certain seasons.

A recent study concluded that "the sonic booms from the Comcorde and Boeing SST's operating during the daytime sometime after 1975,at frequencies presently projected for long-distance supersonic transport of passengers over the United States, will result in extensive social, political, and legal reactions against such flights at the beginning of, during, and after years of exposure of sonic booms from the flights. No data can be found to suggest that any other conclusion is possible."[1] The FAA and other federal agencies and aircraft manufacturers are continuing R&D into possible ways to lessen the intensity or impact of sonic booms. With particular respect to SST airport proposal zone, initial studies made by the Department of the Interior of noise and sonic booms as a new form of environmental pollution should be continued and strengthened, particularly with respect to the effects on fish and wildlife, such as damaging bird eggs or larvae of aquatic life or damaging wildlife having strong audio-sensory characteristics.[2]

The regional jetport facility concept should also be reviewed by other areas in the region such as the agencies conducting comprehensive transportation planning programs in the Detroit region, the Toledo region, as well as the Cleveland area. While such a jetport may be justified on regional needs, the question of regional location is raised and should be answered or verified by region-wide analysis. Such a broader areal analysis would logically be forthcoming from the federal agency such as the Department of Transportation which would be asked

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1 Kryter, Karl D., "Sonic Booms from Supersonic Transport", Science, Vol. 163, 24 January 1969, pp. 359-367.

2 A Report of the Secretary of the Interior of the Special Study Group on Noise and Sonic Boom in Relation to Man, November 4, 1969, Washington, D.C., pp. 28-29.

to provide financial and technical assistance for development of the proposal including the requirement of impact studies on fish and wildlife, coastal processes, and navigation ,and consideration thereof in the final decision for the airport facility. The Federal Aviation Agency has reviewed the project and has endorsed the principle of the concept, but indicates more precise studies will be required before definite commitments can be made.

"While Great Lakes trade has grown in record proportions each year, the share of this cargo carried by U.S. flag vessels has steadily decreased."[1] Part of this decrease is due to the inability of older, slower American lake ships not being able to compete with new, high-speed, foreign-flag vessels in transoceanic shipment; and part is due to truck and rail shipping advantages for Mid-West Atlantic Coast transshipment. Since 1955, the lake fleet itself has declined by more than 130 vessels until today less than 250 ships remain in the Great Lakes fleet. Approximately 45% of these vessels were built before 1915, and only 30 new bulk carriers have been added to the fleet since 1950. The two new 1,000-foot bulk carriers presently under construction will be the first new U.S. flag vessels to join the lakes fleet since 1961. Careful study by the Department of Transportation will need to be made to determine the extent to which it is in the national interest to renovate and update the Great Lakes fleet to meet modern transshipment needs, both for intra-lake bulk cargoes and foreign trade. The development of large container and bulk cargo port and ship capacities may change some of the present cost advantages enjoyed by rail and truck shippers to Atlantic Coast shipping points -- chiefly, New York and Baltimore. Policy requiring European-destined U.S. military cargo to be shipped on U.S. bottoms, coupled with

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1 Dingell, John, "The Mounting Problems of Great Lakes Shipping", Maritime, December 1968, pp. 30-32.

the infrequency of U.S. ocean ships to Great Lakes ports, has raised considerable consternation on the part of Great Lakes ports, particularly since a significant amount of such material is manufactured in the Great Lakes region and sent by rail to New York and Baltimore ports for shipment overseas. Besides suggestions of preferential shipping price supports for such cargoes, the new container carriers mentioned earlier being developed by Canada may offer a design concept that U.S. shipbuilders could produce and effectively compete for military and other cargo out of Great Lakes ports, particularly Toledo and Cleveland. Other proposals to better the position or condition of the Great Lakes fleet is to allocate portions of the subsidy extended to other U.S. shippers for construction of new vessels or modernization of old ones to Great Lakes shipping firms. However, since the main factor distinguishing ship design and affecting operation factors in the size of the depth of the St. Lawrence Seaway and Welland Canal, economic study should be given to whether it will in the long run be more feasible to "treat the ships" or "treat the locks". It would appear that to compete effectively on an international trade basis, Great Lakes shipping routes will have to accommodate a wider variety of the new ships evolving in this area. Hopefully, the navigation element of the Great Lakes Basin Commission Comprehensive Framework Study will review this problem. The objective of this study will be "to assess the economic and social benefits derived from navigation development for the Great Lakes Basin and determine the extent, nature, and timing of a development program necessary to meet the requirements of water-borne transportation in the future." The scope of work for the study is as follows:[1]

> (The scope of work)...will include a description of existing transportation networks serving the Great Lakes Region and a detailed discussion of the de-

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1 Comprehensive Framework Study, Great Lakes Basin Commission.

velopment of harbors, channels, and deepening projects which make up the so-called fourth seacoast of the United States. The quantities of commerce moved and the relationship of transportation networks will be assessed and together with economic studies will be used to project water-borne commerce for the planning periods of 1980,2000, and 2020. The importance of non-commercial navigation to the economic and social aspirations of the people of the region will be determined. A framework plan to guide navigational development in the planning period will be stated.

In conclusion, the following measures in marine science and technology are recommended to assist in the development of an efficient, integrated transportation system in the coastal zones of Lake Erie and Lake Superior:

(1) It is recommended that the Department of Transportation develop a policy for the development of an integrated and balanced transportation system in the coastal zone of the Great Lakes region and related areas. In this effort, it is recommended that the Marine Science Council and the Corps of Engineers and the Maritime Administration cooperate with the Department of Transportation in identifying and formulating the policy elements concerned with marine transport including:

a. The support of R&D to develop requirements for developing port and marine terminal and ship design standards to facilitate efficient transport and intermodal transfer of cargo and passengers.

b. In cooperation with state and local agencies, the evaluation of the impact of port and harbor development on:

1) The pattern of population distribution and economic development in the lake basins to assure such development achieves objectives of optimum development as supported by the designated regional planning agency for the basin; and

2) Fish and wildlife and coastal processes of the lake, so that damage or interruption to these regimes may be minimized, or actually enhanced where possible.

(2) It is recommended that, as a function of transportation policy in the Great Lakes region, the Department of Transportation be delegated the lead agency to coordinate the following R&D needs (some of which are already underway) with the appropriate agencies, including the Corps of Engineers, Coast Guard, Maritime Administration, Federal Aviation Agency, St. Lawrence Seaway Development Corporation, the Great Lakes Basin Commission, and appropriate state and local agencies as may be appropriate for particular studies:

a. R&D on improved ship design to reduce fuel costs and to improve speed of cargo handling, both bulk and container;

b. R&D on new ship design such as hydrofoils and hydroskimmers;

c. Forecasting regional requirements for port capacity, docking facilities, and canal lock capacity;

d. Studies on economic advantages in extending shipping season, including R&D in predicting ice formation and breakup;

e. R&D to improve icebreaker performance, including modification of ships to break moderately thick ice (Alexbow, strengthened bows and bottoms, improved bow design);

f. Charting or removal of navigation hazards (underwater rocks, oil and gas drilling platforms);

g. Navigation and safety aids to shipping.

Recreation.--In 1959, the Department of the Interior and the National Park Service conducted a Great Lakes Shoreline Recreation Area Survey.[1] The survey indicated a "total"[2] shoreline of 5,480 miles including 1,480 miles on offshore islands. Only 710 miles (13%) at that time were in public ownership, of which 694 miles were existing shoreline available to the public. Another 426 miles of privately owned shoreline were identified as possessing important opportunities for use in recreation and other public benefits. These were divided among 66 individual areas with 40 in Michigan, 8 in New York, 7 in Wisconsin, 6 in Ohio, 2 in Minnesota, and one each in Illinois, Indiana, and Pennsylvania.

While the Great Lakes Basin is generally well endowed with public land and fresh water-oriented recreation potential, less than 2% of the Lake Erie Basin is devoted to public recreation;[3] and while large portions of the Lake Superior hinterland are owned by state and natural forests and state parks, public access to the shoreline is becoming increasingly limited. Only 10% to 15% of the shoreline is publicly owned.

The 1,100 miles of Lake Superior shoreline are characterized by spectacular scenic views, rugged terrain and waterfalls interspersed with small pebble beaches, and occasional lowlands and marshes. The pristine waters are backdropped by vast forests. Minnesota's North Shore Drive -- now of freeway standard -- provides an access to the 150-mile stretch from Duluth to the Canadian border. Only about 10% of this shoreline reach is publicly owned. Wisconsin's 325 miles of shoreline include 175 miles on the Apostle Islands and the Kakagon and Bad River Marshes of important significance to migratory waterfowl. The 23 Apostle Islands have been proposed as a National Park.[4] The opening of the Straits of Mackinac Bridge has improved access to Michigan's Upper Peninsula shoreline of Lake Superior. Sixteen

1 Remaining Shoreline Opportunities, Great Lakes Shoreline Recreation Area Survey, 1959, Department of the Interior and the National Park Service, Washington, D. C.

2 The "total" shoreline included the lake ends, connecting waterways and outlets to the sea.

3 Water Oriented Outdoor Recreation -- Lake Erie Basin, U.S. Bureau of Outdoor Recreation, Central Region, Ann Arbor, Michigan, August 1966, p. 2-1.

4 Ringgold, Nancy Rainer, "Discover the Ancient Apostle Islands", Boating, March 1969, pp. 43-46.

percent of Michigan's mainland shoreline of Lake Superior is under public ownership. Isle Royale National Park is the principal offshore feature now publically owned. The recreation use of Lake Superior is hampered by short summer season, cold waters, frequent inclement weather and distance from major metropolitan population centers where shorter vacation, weedend and day use recreation demand is highest. To tap the longer travel tourist market, the Upper Great Lakes Regional Commission is embarking on a program to assist states and local governments in the development of a year-around recreation and tourist program focusing on (1) establishment of a network of national parks, lakeshores and rivers, (2) restoration of fisheries, lakes and shores, (3) development of (coho) salmon and trout fisheries, including the development of spawning grounds, (4) small craft harbor development, (5) lamprey control, and (6) environmental improvement, including the use of senior citizens and other unemployed and underemployed to maintain the appearance of recreation areas.[1]

Industrial, commercial, and residential development have committed only about one-third of the shoreline of Lake Superior. Considerable prime recreation and fish and wildlife potential are available along this sparsely populated shoreline. The Lake Superior shoreline provides a natural or wilderness-oriented shoreline recreational potential. This natural resource potential exists in the form of the present relatively unmarked shoreline -- except the Taconite tailings dumping at Silver Bay, Minnesota, or the copper mining at Keweenaw Peninsula and the few urban centers -- Duluth, Superior, and Marquette. The exploitation of this potential will depend upon the extent to which this natural resource is able to be preserved, including development of policies and zoning regulations to keep development set back from the shoreline, to prevent water pollution, and to blend shoreline development with the landscape. Activity-wise, the low temperature waters of Lake Superior discourage extensive swimming activity, the exception being the warmer waters near the thermal heat outflow from the power plant at Marquette. The provisions of more frequent harbors of refuge, better charting and weather, forecasting, navigation

1. By Personal Communication with Dennis Stravros, Upper Great Lakes Regional Commission.

aids, and marina facilities could increase recreation boating activity on Lake Superior.

While economic development of the Lake Superior Basin will continue to command its place along the shoreline, the scenic beauty and pristine character of Lake Superior is a truly unique resource in the United States and, for that matter, in the world. It is for this reason that the ethic of preservation of environmental quality stands out as a policy guideline, both for the continued development and exploitation of the natural resources in the lake and basin, as well as the recognition of the potential economic benefits of environmental preservation. As the years pass and areas of such high environmental quality become more scarce -- as is rapidly becoming the case -- it may, indeed, be that the economic justification for preservation of environmental quality will be increasingly powerful.

In the Lake Erie Basin, Michigan's shorëline from the Michigan-Ohio state line northward is relatively committed to private and industrial development along western Lake Erie, including the waterfront industries of the Detroit River, the private estates of Lake St. Clair, and the private developments of the St. Clair River, In public ownership along the Michigan shoreline are some 40 miles of wildlife areas in the marshes along Lakes Erie and St. Clair (and Saginaw Bay in Lake Huron), and another 15 miles of parks -- 10 of which are in the Detroit area.[1]

Over half of the United States shore of Lake Erie lies in Ohio, which -- including islands and Sandusky Bay -- amounts to 321 miles:[2]

> There are four main islands in American waters: Kelly's Island, South Bass, Middle Bass, and North Bass Islands. Agriculture, fishing and tourism are their principal economic stays. An island vacation has great appeal, and state parks of sufficient size stressing camping as a primary feature could be expected to receive considerable visitation.
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> From the vicinity of Vermilion to the Pennsylvania line is the shore bluff sector. This segment of Lake Erie compares with the most heavily developed shores on the Great Lakes. A vast complex of marinas, private beaches, exclusive developments, and industrial operations crowd to the edge of the eroding bluffs. Since the natural scene has long been altered, since development is essentially complete, little possibility exists of obtaining natural frontage for public recreation along this section.

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[1] Remaining Shoreline Opportunities, op. cit., p. 139

[2] Ibid., p. 150

One of the outstanding recreation features in Lake Erie is found at Presque Isle State Park in Pennsylvania. Presque Isle is a 7.3 mile spit which sweeps out from Pennsylvania's 51-mile shoreline and serves as a good example of multiple use of beaches, marina, wildlife, and navigation successfully functioning together. The Army Corps of Engineers completed a large beach restoration project along the seaward side of the spit; and a multimillion dollar park improvement program is now under way to provide much needed facilities for public recreation.[1] This area is situated so that little algal pollution is felt, although its rate of use has been hurt by the adverse image of Lake Erie pollution.

New York's 77 miles of Lake Erie shoreline has been developed to such an extent as to nearly preclude further possibilities for recreation access beyond the two state parks (including the one at Niagara Falls).[2] Deficiencies in recreation access may be met along the New York shoreline by increasing new land through filling as discussed in an earlier section, particularly around the Buffalo area.

The shoreline of Lake Erie and Lake St. Clair is more intensely developed than any other shoreline of the Great Lakes. The population of over 10 million in the Lake Erie Basin is expected to double in the next 50 years.[3] Present demand for water-oriented outdoor recreation in the Lake Erie Basin exceeds 245 million activity days annually. Of this, 108 million activity days are for water-dependent activities, 70 million of which occur during the summer months. Demand is expected to triple by the year 2000. Of the basin land area (which is several times wider than the narrow coastal zone margin) less than 2% is devoted to public recreation. This is estimated to be half of the developed public acreage needed to meet present demand for outdoor recreation. Information is not available to discern the extent to which private recreation development is serving to fill this gap. While 15% of public ownership of the shoreline is considered optimum for satisfactory public recreation needs,[4] less than 10% of the Lake Erie shoreline has

1 Ibid., p. 169
2 Ibid., p. 175
3 Water Oriented Outdoor Recreation - Lake Erie Basin, op. cit., pp. 2-1 to 2-2
4 Remaining Shoreline Opportunities, op. cit., p. 175

been acquired for public recreation use.[1] The U. S. portion of the Lake Erie shore has only a few good sand beaches and adequate natural harbors for water-dependent/ activities. The basin lacks inland lakes suitable for water-oriented /outdoor recreation activities; and, most importantly, day-use, water-oriented recreational facilities around the large metropolitan areas are critically lacking. The report Water Oriented Outdoor Recreation -- Lake Erie Basin -- which is referred to frequently throughout this section -- makes the following conclusions with respect to recreation use of Lake Erie:[2]

(1) By the year 2000, recreation demands in the Basin will more than triple for most activities.

(2) The United States portion of the Lake Erie shore has few good sand beaches and adequate natural harbors for water-dependent activities.

(3) The Basin lacks inland lakes suitable for water-oriented outdoor recreation activities. Presently, there is less than one-hundredth of an acre of inland lake water per Basin inhabitant.

(4) Day use water-oriented recreational facilities which serve the SMSA (Standard Metropolitan Statistical Area) counties of the Basin are critically lacking.

(5) Relating expansion of existing facilities and creation of new areas to projected demands, it appears probable that shortages of recreation areas will continue to grow. Among the paramount factors causing the present situation are: (a) poor water quality in and adjacent to the metropolitan centers of the Basin, (b) lack of public access to water for recreational use, and (c)inadequate funds to plan, acquire, and develop needed facilities.

(6) Industrial and domestic pollutants have contaminated portions of Lake Erie and several rivers within the Basin to the extent that their recreational value has been impaired. Local adverse water quality has (1) inhibited use of many developed recreation areas, (2) resulted in abandonment of recreation developments, and (3) discouraged development of new recreation units.

(7) In some instances, recreationists who have year-around homes, which were formerly used as summer cottages, along the shores of water bodies in the Basin contribute to water quality deterioration through overloading sanitation facilities. In addition, litter scattered around recreational areas has weakened the aesthetic quality of many sites.

(8) The greatest natural resource asset of the Basin from a recreational standpoint is Lake Erie and its adjacent shoreline. Less than ten percent of the Lake shoreline has been acquired for all types of public recreational use.

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1 Water-Oriented Outdoor Recreation - Lake Erie Basin, op. cit., p. 3

2 Ibid.

At a recent conference held on the problems of the Great Lakes, the following statement was made which fairly well describes the popular image of the problems of recreation use of the Great Lakes and, particularly, Lake Erie:[1]

> Recreation -- although low in legal priority, many of the 25 million people in the Great Lakes Basin enjoy the recreational advantages of living adjacent to this great resource. The aesthetic value obtained from the mere ability to sit and contemplate the Lakes has, fortunately, not been lost. The beaches of Lakes Ontario, Erie, and lower Michigan have been made unsafe by pollution, as evidenced by bacterial counts, and unappealing through algae growth. Erosion has caused the loss of further shore bathing facilities and has restricted the use of shore-based boats in many areas. Water level variation has caused further loss of beaches and recreation facilities. Other interests however, such as power, navigation, and fishing have not provided any serious restriction to recreational appeal; indeed, they have often improved it. Pollution threatens to end it.

Water pollution, indeed, has been a major problem impairing recreation use of the shoreline and waters of Lake Erie, with the exceptions of the lakeward beaches of Presque Isle State Park in Pennsylvania and Cedar Point, and East Harbor and Crane Creek beaches of Ohio.[2] On the field trip conducted by the NPA Great Lakes Study staff, many recreation beaches were visited that were cluttered with dead fish or covered with decaying algae from a few inches to several feet in depth. However, there were also beaches encountered that had practically no traces of algae and whose waters were crystal clear. A representative of the Erie, Pennsylvania Chamber of Commerce complained that the publicity shouting of Lake Erie pollution was out of proportion and was not true of conditions around Presque Isle State Park and many other locations. Subsequent inspection of that State Parks beaches verified the Chamber representative's concern (however, beach erosion was still a critical problem). The municipal beach at Hamburg, New York utilized a paddle wheel device to generate a lateral current to wash toward shore algae that had accumulated during the night. A tractor-drawn rake then culled it from the lake. Another state park with lesser overnight accumulation of algae simply had the lifeguards turn out early with rakes and a wheelbarrow; and with an hour or so

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1 Clevenger, R. F. and MacLaren, J. W., "New Requirements in Water Resources Plannir On the Great Lakes," Proceedings of the Great Lakes Water Resources Conference, Toronto, Canada, June 24-26, 1968. (American Society of Civil Engineers and the Engineering Institute of Canada), p. 375

2 Water-Oriented Outdoor Recreation -- Lake Erie Basin, op. cit., p. 2-1.

of effort, the swimming area was cleaned of a relatively small amount of green algae deposited during the night. Geneva-on-the-Lake, a resort area between Erie and Cleveland, was reported to have experienced a 40% decrease in tourist trade in the last few seasons "due to the pollution." Inspection of the beaches in this area did not reveal excessive accumulation such as experienced in some of the worst areas of Lake Erie. Upon further reflection on the resort community itself, it is possible that recreation activity and tourist travel patterns have changed so that a resort community once popular in the 1940's and 50's no longer attracts peak loads because its accommodations are less modern or appealing, among other reasons. Although our field inspection around the south shore of Lake Erie demonstrated the severity of pollution effects on recreation areas, it was also evident that the natural circulation waste discharge locations and other ecological conditions affect the concentration of algae and other pollutants from one place to another. The paddle wheel device at Hamburg suggests that artificial structures or devices could be introduced to help clear recreation shoreline frontage by utilizing natural current forces or harvesting apparatus. Other specific kinds of pollution, such as excess bacteria counts prohibiting swimming, will need to be controlled at their sources.

A broad analysis of the influence of poor water quality on the single activity of swimming was made by the Bureau of Outdoor Recreation to indicate the value that pollution control would have on recreation. Table ___ indicates that control of pollution in presently affected areas would increase swimming by 6 milli activity days annually. Since future demand for swimming will multiply significantly, it is evident that improved water quality in the Lake Erie Basin is most important to public enjoyment of this recreation activity. "If the water quality of the lake and its tributaries were improved, public agencies would be more prone to consider additional beach development. As an example, the city of Toledo with more than 300,000 people is adjacent to the shores of Lake Erie and has no public swimming facilities along the shore. There is little inclination to provide swimming facilities under present water quality conditions. Under suitable water quality conditions, public pressure could very well cause such facilities to be provided. The Cleveland Regional Planning Commission estimates thr four country areas of Cuyahoga, Lorain, Lake and Geauga will need 81 additional acres of beach by 1970. Emphasis could be placed on acquisition along the Lake Erie shore if water quality were improved to permit swimming in areas acquired.[1]

In some instances, recreationists who have year-around homes, which were formerly used as summer cottages along the shores of water bodies in the basin, contribute to water quality deterioration through overloading sanitation facilities. In addition, litter scattered around recreational areas has weakened the aesthetic quality of many sites; and sanitation waste from recreation boating has contributed significantly to the pollution problem in areas of heavy use.

The implementation of water quality standards adopted by the states in the Lake Erie Basin will contribute significantly to enhancing recreation use of the shoreline and waters. The restoration of the major tributaries of the lake and certain near-shore areas through dredging polluted bottom sediments may also serve

TABLE [2]

ESTIMATED INFLUENCE OF WATER QUALITY ON SWIMMING ACTIVITY AT PUBLIC BEACHES
LAKE ERIE BASIN

Estimated swimming activity at public beaches (1963)	$16,455,000
Estimated swimming activity atpublic beaches which frequently exhibit poor water quality and should be closed (1963)	780,000
Estimated swimming activities without water quality improvement	15,675,000
Increase in swimming activity with improved water quality	
Reopening of closed beaches	1,325,000
Increased participation by present patrons	2,640,000
Increased attendance participation	2,625,000
Total increase	6,590,000
Estimated swimming activity with improved water quality	23,045,000
Annual loss without improved conditions & with enforcement	7,370,000

1 *Ibid.*, p. 9-9

2 *Water-Oriented Outdoor Recreation — Lake Erie Basin*, *op. cit.*, p. 9-9.

to restore recreation areas that have been abandoned. Further research needs to be directed toward developing water quality criteria for public health standards in recreation use of lake waters, particularly for swimming and other water sport activities. Such a research program was initiated at the FWPCA Water Quality Laboratory at Duluth and could be further supported.

Various kinds of shoreline modifications and structures could be introduced to enhance recreation use of the shoreline. These include the use of land fills and excavation techniques described in an earlier section, particularly with respect to "stretching" the shoreline in the critically deficient day-use zone near metropolitan areas. Such deficiencies could also be met for recreation purposes by acquiring new lands away from urban centers and by rehabilitating urban waterfronts. With respect to the latter, a variety of new kinds of bank shapes, erosion protection structures, and materials may be explored to develop attractive and efficient designs of waterfront architecture to enhance recreation use and aesthetic quality. The Governor of New York as part of a recreation land plan proposed to increase state and local efforts to provide free or low-cost transportation from urban poverty areas to recreation areas through appropriate federal support.[1] As many large cities along the Lake Erie shore, such as Buffalo and Detroit, have had to purchase shoreline recreation access further away from the central city waterfront, this proposal has merit in providing recreation opportunity for the increasing proportion of economically disadvantaged citizens in the core areas of larger cities.

Preservation of the overall Great Lakes Basin environment is to be studied by the National Park Service in the Great Lakes Basin Commission's Comprehensive Framework Study. NPS is conducting an "Environmental Study of the Aesthetic and Cultural Values of the Great Lakes Basin" to obtain an evaluation of the total environment within the study area and to provide a broad-scale analysis of the factors that affect the aesthetic qualities and cultural values, isolating definite problems as they relate to the river basin study and identifying resource potentials of

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1 "New York Governor Proposes Recreation Land Plan," Parks and Recreation, September 1968, p. 11

an aesthetic or cultural nature. Hopefully, this study will provide policy guidelines to direct R&D to the engineering aspects of environmental quality, such as architectural design considerations for shoreline modification and protection structures.

The importance of preserving the scenic and aesthetic quality of the coastal zone to enhance the tourist industry can be seen in the startling difference between Niagara Falls, New York and Niagara Falls, Ontario. "Ringing the clean but unimpressive state park in the American city is a downtown of unsightly two and three story buildings and honky-tonk souvenir shops. But once across the Rainbow Bridge, which connects the two countries, tourists find themselves in a setting of beautifully shrubbed and multicolored gardens and trees, several observation towers, good restaurants, and two large hotels overlooking the falls."[1] Niagara Falls, New York is now striving to redevelop its city into a more attractive and effective tourist-oriented service and commercial center, recognizing tourism as a valuable industry rather than a nuisance.

As part of the IJC's Great Lakes Water Levels Board shore property investigation, the Bureau of Outdoor Recreation is conducting an investigation to measure the effects of change on beaches resulting from regulation of water levels. The study will measure present-day user capability of the beach shore zone for swimming and the change in capability -- quantitatively and qualitatively -- associated with the lowering of water levels due to regulation during the summer recreation season, which are the two basic benefits of regulation.

There are over one million registered boats in the Great Lakes states, and twenty-eight percent of the population in the Great Lakes Region participated in boating on one or more occasions annually. This level of boating interest is on a par with the New England Region, which is highest in the Nation. There are certain measures that can be taken to increase boating activity and enjoyment and, at the same time, still increase the recreation boating base. The problems of squalls

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[1] "Luring the Tourist to the American Side," Business Week, Nov. 9, 1968, p. 133

quickly rising and rapid fog developing which tend to restrict boating close to shore or near to harbors could be reduced by the availability of the several new FM emergency frequencies established recently by the Federal Communications Commission to handle distress signals and to monitor weather forecasting and other information.[1] Combined with the development and marketing of low-cost radio equipment for small craft and the provision of better navigation aids, such as the new Corps of Engineers Lake Survey District Recreation Boating Map for western Lake Erie and better weather forecasting during the summer recreation boating season, these efforts would encourage wider use of small craft use. Additionally, the provision of harbors of refuge--especially along the shoreline of Lake Superior--as discussed in the section on "Modifications of the Shoreline," would encourage recreation boating activity.

While there is a large demand for slip rentals -- and in some areas near the metropolitan shoreline, the provision of additional marina facilities per se does not necessarily induce increased boating activity. Marine operators are primarily concerned with servicing resident boaters, particularly larger craft; and, therefore, transient small craft services are not adequately provided. There is need for a greater number of widespread public boat landing ramps as a function of access to the shoreline and waters of Lake Erie. The public ramps at Buffalo and Barcelona are examples of the kind of facilities needed. From an institutional standpoint, coordination of state, local, and federal safety and navigation, registration and taxing laws and requirements would benefit recreation boaters. Additionally, participation rates in recreation boating are highest in the skilled and semi-skilled workers in the many manufacturing and industrial centers around Lake Erie and Lake Superior. The changing of vacation patterns in industry could have significant impact on the number and frequency of boating occasions -- as well as other recreation activities in the lakes which are subject to congestion during peak periods, such as beaches.

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1 Humphrey, Richard, "VHF-FM Begins to be Felt in Marine Radio," <u>National Fisherman</u>, October 1968, p. 21-A and 31-A.

The coho salmon stocking program has not been as successful in Lake Superior as it has been in Lake Michigan.[1] Initial plantings were made in the turbulence of these two lakes during the Spring of 1966. While the coho salmon thrives in Lake Superior and is stimulating increasing sport fishing activity, these fish are smaller than those in Lake Michigan; and the percentage surviving from the 1966 planting was substantially lower. This is primarily because alewives, upon which coho largely feed, have not attained the abudance in Lake Superior as they have in Lake Michigan. The success of coho or other species of salmon surviving under the conditions of accelerated eutrophication in Lake Erie is still largely unknown. In 1966, a "few" fingerlings (20,000) were released in Lake Erie and have been reportedly appearing in commerical fishing nets up to 5 pounds in size. Other encouraging indications for developing a coho sport salmon fishery in Lake Erie are due to the results of experimental stocking in early 1968 of 6,000 cohos that are 1[illegible] months old and 5-6 inches long in Cattaraugue Creek, a New York tributary to Lake Erie.[2] Indications of the success of this experiment were found by the return of some of the early maturing males in the fall of 1968 (a year earlier than normal). However, some of the early returning cohos have been killed by apparently high water temperatures in the stream. Unless some measures can be developed to increase flows in Cattaraugue Creek to decrease the warm daytime termperatures, it appears that only the fish which run at night with lower water temperatures will survive their upstream migration in Lake Erie tributaries. Through R&D in selective breeding, it is possible that a species may be developed to survive in the warmer water temperatures.

The possibility of establishing a coho salmon fishery has met with mixed emotions. On the one hand, the potential development of a sport fishery would offer both increased recreation opportunity and economic value. On the other hand, commercial fishermen are concerned over the possibility that the predator coho will

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[1] "Lake Michigan: Salmon Help to Redress the Balance," Science, August 9, 1968, pp. 55[illegible] 555.

[2] "New York Hopeful as Cohos Survive in Lakes," National Fisherman, November 1968, p.

further deplete the commercial lake perch fishery and the alewife and trash fish populations upon which a fish meal industry may develop. Both the commercial sport fishing values will have to be carefully weighed to determine the short and long rang economic advantage between these two uses of the fishery potential of Lake Erie. The recreation values, expressed either in terms of economic value or political preference of the population within the basin, may still be the overriding factor in choosing between these two uses. Additionally, the latter choice may be made upon information and considerations beyond the scientific scope of the fisheries biologist which further demonstrates the interdisciplinary nature of the decision-making process for optimum resource utilization.

The overall approach to enhancing recreation use of the coastal zone involves measures both to increase the quantity of shoreline for providing access to the lakes and along the shoreline for recreation activity, and to maintain and enhance--and, in certain cases, restore-- the quality of the shoreline and water environment for recreation. Various recreation planning studies have been, and are currently, under way which include the study of multiple use of lands and waters; resource inventories to determine priority areas for acquisition, management needs, (e.g. shore protection) and use classification; and development and implementation of water quality standards for anhancing recreation use of shoreline and water resources. There are areas in which R&D could be conducted in conjunction with these planning efforts to find better ways of utilizing the shoreline and waters for recreation purposes. For instance, as discussed in the section on "Modification of the Coastal Zone", R&D on the development of new land fill and excavation techniques could provide new possibilities for increasing or "stretching" the shoreline including ways to utilize various solid waste materials in land fills. The development of new engineering techniques and development standards could enhance multipurpose use of shoreline and harbors. For instance, new shapes in shoreline bank and wharf configuration could be designed to facilitate recreation use during, say, slack shipping periods. Along with pollution abatement and restoration program combined landscape and engineering design studies could develop new approaches for integrating fish and wildlife habitat within urban waterfront areas.

One particularly important vehicle for coordinating shoreline recreation use around the Lake Erie and Superior Basins is available through the procedures of the Federal Land and Water Conservation Fund Program administered by the Bureau of Outdoor Recreation. The L&WCF Program provides funds for planning, acquisition, and development of outdoor recreation areas and facilities. An eligibility requirement for applications for state and local projects is that they be related to or coordinated with a state recreation plan which, in turn, should be coordinated with the comprehensive planning program for the respective state. The recreation element of the Great Lakes Basin Commission's comprehensive framework study could provide the basis for identifying regional recreation needs and deficiences as well as develop the standards and policies for assessing the regional significance of projects proposed in a local area -- and which should, thereby, receive regional endorsement for priority consideration, such as in the area of acquisition needs. Such regional endorsement could be a consideration in Land and Water Conservation Fund Project review.

The following recommendations are made to enhance the optimum use of recreatio resources in the coastal zone of Lakes Erie and Superior:

(1) It is recommended that the appropriate regional planning agency for the lake basins identify priority areas of shoreline access and other water-oriented recreation deficiencies as a basis for determining cost-effectiveness and coordinating the allocation of federal contributions for acquisition and the development of recreation areas and facilities to the greatest benefit to the region.

(2) It is recommended that priority consideration be given to conducting R&D in development techniques for increasing shoreline access in urban areas for recreational uses through:

(a) Use of land fills and excavation.

(b) Rehabilitation of urban waterfronts from derelict commercial and industrial uses to recreation use.

(3) It is recommended that R&D be conducted to develop improved marine and wildlife species, management techniques, and use regulations to enable the establishment of natural fish and wildlife areas within urban reaches of the shoreline on a multiple-use base. It is further recommended that the Bureau of Sport Fisheries and Wildlife be given lead responsibility for this recommendation, in cooperation with state and local governmental agencies and the Department of Housing and Urban Development.

(4) It is recommended that R&D be conducted in developing engineering designs for shore protection structures, piers and wharves, and other waterfront and lake bank management methods that are aesthetically attractive and will serve to enhance the quality of the urban shoreline environment. It is further recommended that the Council maintain lead responsibility in this recommendation and cooperate with the U. S. Army Corps of Engineers and the Department of Housing and Urban Development.

(5) It is recommended that the Recreation Craft Series nautical charts published by the Lake Survey District be extended to the entire shorelines of Lake Erie and Lake Superior and include such shoreline recreation facilities as state and local parks and other significant public water-oriented recreation features of interest to the recreation boater.

(6) It is recommended that priority consideration be given to providing assistance to states and local government in carrying out pollution abatement restoration programs in the proximity of water-oriented shoreline recreation areas. It is also recommended that emphasis be given to R&D for developing waste management systems that are compatible with or enhance recreation use of the shoreline, such as the use of solid waste materials to develop recreation-oriented land fill projects or the use of thermal effluents to warm swimming waters.

(7) It is recommended that the preservation of the quality of the environment of the shoreline and waters of Lake Superior be given priority consideration in the formulation and implementation of water quality standards, zoning regulations for the use of the shoreline and waters, and policies for the management of the resources of the narrow coastal zone of the Lake Superior Basin.

<u>Commercial fisheries</u> -- While progress is being made in sea lamprey and alewife control as well as pollution abatement and introduction of coho salmon in Lakes Erie and Superior as discussed in the water quality control and recreation sections, the interests of sport and commercial fishing -- or the taking of fish for human comsumption or for fish meal production -- must be reconciled on an "institutional" basis. Additionally, R&D would be useful to develop plant or animal species that would flourish in the over-enriched Lake Erie, or in controlled areas, combining nutrient inputs and waste heat from power plants. For example, a new warm water bass fishery, unique to the region, has developed in the relatively small harbor at Dunkirk, New York due to the raising of water temperature from the heated effluent from an adjacent thermal power plant. The harbcr has become popular with fishermen, especially since the area is open all year round. Also, boats can be kept in the water all year. Such a situation could also work to utilize waste products as well as produce an economic commodity in the form of year-round fish culture (i.e. for a source of animal protein) or large-scale hatchery. The R&D needs in the rehabilitation of the commercial fishing activity in Lake Erie -- or in certain cases, in either Lake Erie or Lake Superior -- or the establishment of new commercial fisheries may be summarized as follows:

- R&D on measures to preserve and improve quality of fishery breeding grounds;
- Research on breeding fish for fast growth and other desired characteristics;
- R&D on fish-hatchery design and low-cost fish food;
- R&D on measures to protect fish eggs and fingerlings from predators;
- Control of sea lampreys and other fish parasites;
- Provision of natural or artificial weed havens and other havens for fish;

- R&D on ecological effects of introducing new fish species to lake;
- R&D on measures to reduce or eliminate undesirable fish from lakes or rivers; including (a). Selective control of breeding grounds to purge undesirable fish or destroy eggs; (b). Sterlilization and / or poisoning of selected species; (c). R&D on processing trash fish for fish meal or fish protein concentrate;
- R&D on techniques of measuring fish populations and maximum sustainable yields, or prediction of hatch and survival rates of fingerlings due to adverse weather during critical periods of early life;
- Conservation measures and fishery management practices including Canadian-American agreements;
- R&D on fish-locating, catching, processing, and marketing technologies;
- R&D on the design, establishment, and management of a large-scale systematic fish-farming program for the entirity of Lake Erie or Lake Superior; and
- Search and rescue services, navigation aids, mapping, weather monitoring and forecasting, port and harbor facilities for commercial fishing operations.

Mineral resources -- The recent discovery of potential oil and gas resources under the bed of Lake Erie and manganese nodules in the northern portion of Lake Michigan[1] has triggered attention to the possibility of increasing drilling and mining activities in the Great Lakes. Present controversies over pollution arising from dredging and excavation operations in the Great Lakes, and notoriety from arguments over pollution and navigation hazards and scenic pollution from off-shore drilling rigs along the Southern California and Gulf Coast States (pointed to by local Lake Erie conservationists, among others) have stirred considerable reluctance on the part of state regulatory agencies to allow or encourage private companies to go in and develop these resources. The strengthening of R&D in (1) developing regulations for drilling and mining operations and reconciliation of these activities with other uses of the coastal zone, and (2) acquiring the data and information, and production technologies to substantiate

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1 Rossman, R. and Chandler, E., "Manganese Nodules in Lake Michigan," Science Vol. 162, December 6, 1962, pp. 1123-1124.

commercial exploitation of these resources would contribute to overcoming the risk and uncertainty associated with these activities, particularly those offshore. Of priority importance in this regard is R&D in exploration and development technologies for oil and gas and other mineral resources under the Great Lakes and along the shoreline; competitive technologies for mining, beneficiating, and refining of ores presently of marginal or submarginal quality in or adjacent to the coastal zone; forecasts of mineral resource developments in the coastal zone or requiring transport in the coastal zone; and development of measures and methods to control pollution and navigation haaards and aesthetic degradation to the coastal environment from offshore drilling and mining and oil spills.

Agriculture and forestry -- Conflicts in urban and agricultural use of the coastal zone increase steadily with the expansion of urban and industrial uses displacing agricultural land. This is particularly true in the intensive vegetable and fruit producing areas located near urban market centers around Lake Erie. Urbanization produces other probdems resulting in a reduction of agricultural acreage or crop damage -- such as air pollution, erosion caused by excess runoff due to a natural growth cover being replaced by asphalt streets and composition roofs, pilferage and vandalism of crops, increasing property taxes, and interruption of efficient crop management patterns by leap-frogging and scattering urban expansion. On the other hand, efforts to intensify agricultural production through the use of fertilizers, herbicides, and pesticides have caused considerable problems in pollution of urban water supplies and damage to the natural ecology of the coastal zone.

Of particular importance to the coastal zone are the soil which, due to combined unique nutrient characteristics and coastal climatic conditions, produce speciality crops such as certain varieties of fruits and wine grapes. Such crops are virtually assured of steadily increasing markets in the future because of the great difficulty in reproducing these varieties anywhere else. Consequently, these areas should be preserved, both for the benefit of maintaining the economic and food value of their production, and for the additional social and aesthetic value. These lands lend variety and attractiveness to the landscape of the coastal zone. Agricultural lands, as an element of open-space planning, have additional usefulness of providing space for dilution of airborne waste materials -- in a sense, an "airshed," and for buffer areas preserving community identification, shaping urban expansion, and segregating conflicting uses.

The priority R& D needs for effectively utilizing the agricultural and forestry resources of the coastal zone include R& D on increasing agricultural and forestry productivities or crops or species suitable to the coastal zone; forecasts of agricultural and forestry yields in the coastal zone or requiring transport in the coastal zone; and research on determining the soil climate characteristic unique to the coastal environment, including R& D to develop methods to preserve and enhance the utilization of these lands, in terms of agricultural production and other benefits which may be derived from open space land, and agricultural practices which will not have detrimental effect on the coastal zone environment, particularly with respect to water run off causing soil erosion and deposition, and carrying fertilizer and pesticide residues and livestock run off wastes to the lakes.

Industrial development -- Marine science and technology is involved in the industrial growth and development of the coastal zone in two main ways. First there is the science and technology required to develop rationally those marine resources upon which industry may develop. This includes the development of new or improved technologies necessary to utilize the Great Lakes more effectively as a transport artery, a recreation resource, a power resource, and as a source for raw materials -- water, fisheries and minerals. Second, and as discussed in Part I, a related technology must be developed to oppose the forces impinging on the quality and quantity of this industrial base resulting from (1) the by-products of waste from the industrial process itself, and (2) the imbalance of the resource base due to excessive competition for a single purpose use, such as witnessed in the problems presently associated with the industrial use of fresh water supplies.

Priority needs for R&D to enhance the resource base and growth potential for industry in the coastal zone may include R&D on measures to develop or introduce the most efficient marine-related manufacturing or processing technologies to the coastal zone; requirements for zoning of industrial land use or other regulatory measures to control possible adverse impacts of industrial development on other priority uses of the coastal zone; criteria for assessing priorities allocating marine-orientated resources between various industrial sectors, and between industrial and non-industrial uses.

Urban development -- Marine science and technology has an important role in the urban process within the coastal zone. The large cities located on the shoreline of Lake Erie, including Detroit (on the Detroit River), clearly demonstrate how the physical characteristics of the shoreline and the availability of, and access to, the Lake's waters have influenced the pattern and activity of the urban environment. Furthermore, the urban waterfront presents a dramatic cross section of the technical, physical economic and social problems that confront virtually every major American city today. The marine scientist and engineer, working in any discipline and standing at the waterfront of any city around Lake Erie can readily see water pollution, urban blight, derelict wharfage structures -- and for a brief period during the summer of 1968 -- the flames from burning buildings ignited over growing social turmoil. It may well be that it is within the context of the urban environment that marine science and technology can contribute most to solving the problems of the coastal zone, in terms of both developing solutions to existing problems, and inintroducing the role of marine science and technology to the urban (comprehensive) planning and decision-making process of coastal cities. It is also in the urban portions of the coast zones of Lake Erie and Lake Superior that the multiple use of the resources of the coastal zone is in most demand, while at the same time come into greatest conflict.

To contribute to the development of remedial programs to solve the above problems and enhance the optimum use of urban water fronts, it is recommended that the Marine Science Council, in cooperation with other concerned agencies -- such as the Department of Housing and Urban Development, and the Water Resources Council -- support a broader range of studies to identify the role of, and needs for, marine science and technology in the conduct of comprehensive urban planning programs of federal, state, regional and local governments. These studies should include integration of the coastal zone as a geographic or functional unit of the comprehensive planning process and seek to identify and pursue specific scientific and engineering R&D to expand the alternatives available for solving urban waterfront problems including (a) waterfront land use and redevelopment stressing water-orientated activities; (b) physical design or construction standards and code modifications for shoreline and offshore facilities, and (c)

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measures to develop intensive residential, commercial or recreation facilities in coastal urban areas -- including the provision of areas of natural plant and animal life within the urban waterfront. Also of basic importance in these studies is the determination of the physical and ecological limits of coastal zone resources to accomodate and support urban uses. These studies would include development of guidelines on population saturation densities to protect resources, and the development of alternative approaches to encouraging selective dispersion of population and urban development into sparsely populated areas of the coastal zone or hinterland to relieve pressures upon presently overstressed natural resources in the coastal strip.

Power development -- The waters of Lake Erie and Lake Superior and their tributaries provide the basis for development of power resources by providing a source of: (1) hydraulic power to run generators, and (2) fresh water for steam and cooling systems in thermal power plants. The major problem in the use of Lake Erie as a source of hydraulic power generation stems from the need to maintain lake levels sufficiently high to sustain minimum flows. In the multiple use of lake waters, the regulation of lake levels to meet variations in power demand is sometimes in conflict with other uses. For instance, increased outflow for power generation purposes during periods of low lake levels would increase navigation and shipping costs, or the restricting of outflow during low demand periods and high lake levels increases or prolongs flood and property damage hazards.

The difficulty of maintaining normal levels in Lake Erie results from a combination of factors. One is the wide ranges in rainfall and the need to store the runoff waters in the lake due to the restricted discharge capacity of the

Niagara River. This causes high levels during periods of excessive rainfall. Another factor is reflected in low levels occasioned by the unregulated inflow from Lake Huron through the St. Clair and Detroit Rivers during periods of low rainfall. Ice conditions during winter months also cause decreased flow through the Niagara River. Thus, to sustain normal levels in the face of varying flow-through demands for power generation and the desirability to sustain normal lake levels to compromise the variety of user interests in and around the lake, a system of regulatory structures and diversions is needed to "pull the plug" during excessively high levels, or to increase inflows during periods of low levels. The outlet of Lake Superior contains regulatory structures operated by the International Joint Commission to increase or decrease outflow to maintain normal levels and flows between Lake Superior and Lake Michigan and Lake Huron. Because of the limited capacity (although increased in recent years) of the St. Clair and Detroit Rivers' channel, regulation of Lake Superior outflows has only limited and gradual effects on Lake Erie levels.

Other problems of hydroelectric generation are: (1) siltation of head ponds through soil erosion; (2) compensating navigational interests and shore property interests when creating a sufficient head of water at generating sites[1]; (3) slime control difficulties with pollution (more applicable to thermal power plants). Other means to enhance the hydroelectric potential of Lakes Erie and Superior are to: (1) utilize diversions into the lakes from watersheds outside the basin, especially the Hudson Bay Drainage Basin; (2) develop tributary holding reservoirs, including hydroelectric plants; and (3) increase generating capacity of existing power plants since most of the prime sights have already been committed to use on Lake Erie. (However, some potential exists on the St. Marys River).

[1] MacLaren and Clevenger, op. cit., p. 373

Development of more efficient thermal power generation technology has increased the use of these plants throughout the coastal zone of Lake Erie and Lake Superior and has lessened reliance on hydroelectric power sources. Thermal power plants largely use fossil fuels (coal) as an energy source, but nuclear plants are commercially competitive for large-scale units and are being constructed in the Great Lakes Region(Detroit and Upper Lake Michigan). Thermal plants require large amounts of cooling water and are usually located on the shore of a river, lake,or ocean. Problems associated with thermal power plants include: (1) excessive low lake levels may adversely affect fresh water intakes, (2) lake pollution causing clogging of water intakes and algal slime control problems, and (3) pollution from the power plants in the form of thermal affluent, potential source of nutrient input in fly-ash fills, and air pollution from suspended fly ash and "smoke". Opportunities to enhance thermal power generation in the coastal zone include:

(1) Use of an internal water circulation steam condensing and cooling water system using more efficient cooling towers.

(2) Use of solid waste disposal furnace systems as an energy source for power generation (as being currently considered for use at San Franciscoo, California.[1]

(3) Combining the development of thermal power generator plants with other potentially compatible uses such as swimming, fishing, and boating activity associated with the warm water outfalls of the power plants at Dunkirk, New York, and Marquette, Michigan. While these cases may be pointed to as a relatively successful integration of compatible uses, they were largely by-products of single purpose commitments on the part of the power plant location. The careful consideration of these appropriate uses in the planning stage, including institutional arrangements necessary to assume appropriate project costs allocated on the basis of benefit derived from, for example, the total integrated power generation -- recreation system -- would greatly enhance the overall use-

[1] Air and Water News, July 29, 1968, p.7.

fulness and benefits from the large investments in these utilities.

R&D relative to marine science and technology in developing the power resources of the coastal zone include the following:

- Projections of power requirements to serve the Great Lakes Region and other national and international power networks, including breakdowns for Lake Erie and Lake Superior watersheds including total requirements and type of power source.
- R&D on thermal power plant design, construction, and financing requirements to develop measures to enable and encourage integration with other recreation, urban, and utility uses.
- R&D on efficient power transmission techniques to enable more flexibility in thermal power plant location away from urban power market concentrations.
- R&D to lessen the impact of thermal power plants on the coastal environment for: (a) controlling airborne waste, (b) controlling temperatures of water effluents (to either make warmer or cooler).
- R&D on systems for controlling lake levels.
- R&D on maintaining winter flow-throughs of hydropower plants.
- Research on ecological and marine biological effects of thermal pollution.

Water resources management[1] -- The increasingly competitive demands for use of Great Lakes waters generated by the region's economic and population growth places increased need to systematically manage the water resources of the lake system rather than, say, Lake Erie or Lake Superior on an individual basis. In the broadest sense, management of the lake system involves measures to provide qualities and quantities of resources for a variety of purposes. The purposes of water quality control were discussed in the first section of this working paper. This section is concerned primarily with the quantitative aspects of water management; that is, measures to manage the levels and flows of lake waters for the combined purposes of pollution control, navigation, flood control (including erosion and deposition), power generation, water supply, recreation, and fish

[1] This section is based in large part on Lea, op. cit..

and wildlife conservation.

The problems of levels and flows in the Great Lakes stems from two interrelated problems: (1) increasing pollution, and (2) fluctuating levels and flows. For instance, the recent (1965) draught conditions over the Great Lakes watershed resulted in near-rescued lows in levels and corresponding reduced flow through the lakes. These low levels and flows impaired values of navigation, power, and property at an estimated annual rate of $100 million and occurred just when the pollution problem was achieving near-critical proportions in Lake Erie. The general approach to solving the problems of both quality and quantity of water in the Great Lakes involves: (1) more intensive pollution abatement through better waste treatment, and (2) the manipulation of water by regulation of flows and/or diversions to maintain normal lake levels and to dilute any carry away waste pollutants.

Figures in Part II indicate the general physical characteristics and levels of the lakes which vary depending on the climate the topography, and flow of water in the Great Lakes System. At the present time, the only engineering regulation of the system is at the outflow of Lake Superior and Lake Ontario. The manipulation of water levels and flows will involve: (1) the construction of major civil engineering structures, such as dams, locks, and the connecting and/or reversing of rivers; (2) the development and agreement on rational plans which demonstrate hydraulic practicality, benefits which outweigh costs, bureaucratic administrative arrangements, and political acceptance; (3) the multi-purposes of normal levels for pollution control, water supply, navigation, recreation, and fish and wildlife conservation, and (4) flexibility of flows to accommodate flood control and power generation interests. Because of the basin-wide and inter-basin scope of regulating levels and flows of waters into and through the Great Lakes system involving regions of the United States and Canada, the two governments in 1964 charged the International Joint Commission with studying the causes and fluctuations in levels and the practicality and benefits of changes in existing works or other measures.

R&D in, or. related to, marine science and technology needed in the further development of a system of water quantity management in the Great Lakes Basin -- in particular, Lakes Erie and Superior -- are as follows:

- Improved techniques of forecasting annually or seasonally available water resources of the Great Lakes Drainage Basin, including improved long-range weather and precipitation forecasts; improved estimates of evaporation losses; and improved estimates of soil retention of water.

- Hydrological and engineering studies bearing on the practicality of diverting waters from the Hudson Bay Basin Drainage Area to the Upper Great Lakes Basin Drainage Area to increase availability of water resources to the Great Lakes Region.

- Joint Canadian-American studies of the long-range, socio-economic benefits to both countries of diverting Hudson Bay Basin waters to the Great Lakes (and possibly a proposed plan of shared effort in accomplishing the same, if studies are favorable).

- Improved water use management, including

  (a) Forecasts of water requirements of regions drawing on Great Lakes Basin waters and reconciliation of short and long range priorities for competing water uses (recreation, residential,and industrial, marine transportation, hydroelectric power generation).

  (b) R&D on hydraulic methods of controlling water level variations in the Great Lakes (individually and collectively).

  (c) R&D on feasible methods of flushing pollutants from the Great Lakes or portions thereof.

  (d) Improved measures of flood control and flood plain management.

(e) R&D on measures to conserve industrial and residential uses of water (especially for those regions diverting waters from the Great Lakes to other drainage basin areas).

(f) Measures for controlling water quantity.

PART IV

CANADIAN-U.S. COOPERATION IN APPLYING MARINE SCIENCE AND TECHNOLOGY TO MULTIPLE USES OF THE COASTAL ZONE[1]

In addition to the international implications of use of the coastal zone of Lakes Erie and Superior discussed in the sections dealing with the International Joint Commission and the issues concerning Canadian-U.S. relationships in the problem of water quality in the boundary waters of the Great Lakes, a review of the recent organizational innovations instituted by the Canadian Government with respect to planning and research in the Great Lakes reveals important implications for Canadian-U.S. cooperation in the use of the coastal zone. The Great Lakes plays a greater relative role in the well-being of Canada than it does in the United States For instance, while about 30% of total U.S. productivity is generated in the Great Lakes Basin, more than half of Canada's productivity is tied to the Great Lakes and St. Lawrence Basin. Over one-third of the Canadian population is concentrated in the basin system, where only about 14% of the U.S. population resides there. However, as the Great Lakes Basin population is made up of 28 million Americans and 2 million Canadians, the United States still places the greatest demand on the basin's resources.

The division of responsibility for water management in Canada is somewhat similar to the United States. Canadian provinces own and have primary responsibility for the management of the water resources within their boundaries. The Canadian Federal Government is responsible for international waters, inter-provincial waters, and has legislative authority over navigation and fisheries. In the United States, the states have primary authority over fisheries management.

A major difference between the Canadian and U.S. Governmental organization on

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[1]This review draws heavily on the presentation entitled "The Role of Government in Great Lakes Research", presented by Dr. James P. Bruce, Acting Director of the Canadian Center for Inland Waters, at the Great Lakes Research Symposium conducted by the Great Lakes Panel of the Marine Sciences Council, Ann Arbor, Mich.,Oct. 30, 196

the Great Lakes is that Canada essentially has only two provinces involved -- Ontario and, to a lesser extent, Quebec -- whereas the United States has eight states. This jurisdictional arrangement has given Canada an advantage in having a less-complicated task in coordinating water resources management with the two provinces.

Responsibility for research.--The Canadian Federal Government has the major responsibility for sponsorship and conduct of water resources research, particularly with respect to research on international waters which, in the instance of the Great Lakes, has implications and applicability for other water bodies throughout Canada (such as the Great Slave Lake or Lake Winnipeg). The provinces, particularly Ontario also conduct a variety of applied research programs directly related to water resource management needs. For instance, the Ontario Water Resources Commission is concerned with pollution problems; and the Ontario Department of Mines and Forests is concerned with fisheries, both commercial and sport fisheries (particularly, the latter). Universities are also deeply involved in Great Lakes research, particularly the Great Lakes Institute of the University of Toronto, Waterloo University, McMaster University of Western Ontario, and others.

Emphasis placed on Canadian water resources research in the Great Lakes has produced some major new developments. The Science Secretariat -- the Canadian counterpart of the U.S. Office of Science and Technology -- commissioned a survey of water resources research in Canada.[1] The Canadian Science Council also conducted a survey[2] identifying a number of areas in which Canada appears to be undersubscribed in water

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1 Water Resources Research in Canada, Special Study No. 5 of the Science Secretariat.

2 A Major Program of Water Resources Research in Canada, Report No. 3, Canadian Science Council, 1966.

resources research. For instance, the report identified the area of lakes research as being in need of further support, particularly since over 8% of the area of Canada is covered by lakes and because of the economic importance of the lakes to the country. These reports have led to major steps being taken toward increasing water resources research in Canada.

In 1966, the Federal Government designated the Department of Energy, Mines, and Resources as the Federal agency responsible for coordination of Federal water resources for research and management. In this same period, the reference to the International Joint Commission on pollution of Lakes Ontario and Erie was made in response to the IJC which posed three main questions to the Canadian and U.S. Governments: (1) Are the Lakes polluted? (2) Now much of the pollution on the Canadian side comes from the United States and vice versa? (3) What remedial measures should be taken? The need to organize the study effort necessary to respond to these questions was an important factor in the Canadian Federal Government's decision to carry out this organizational plan.

Establishment of a Center for Inland Waters.--It was essentially the occurrence of the above three events: (1) the realizatinn of the need for much-increased support of water resources research in Canada, (2) the requirement for an input to the International Joint Commission's Lake Erie pollution study, and (3) the designation of the Department of Energy, Mines, and Resources as the coordinating Federal agency -- that led to the establishment of the Canada Center for Inland Waters. The concept was that no single discipline nor single agency could alone provide the scientific input (both in the natural and social sciences) needed to permit optimal management of Canada's water resources,in ganeral, and the Great Lakes, in particular. The objective was to establish a major interdisciplinary center to include all of the disciplines relevant to lakes research and the three main Federal departments concern and to provide support to the university community interest in Great Lakes research.

As the lead agency for the Center, the Department of Energy, Mines,and Resources (EM&R) includes funds in its budget for construction of the Center and for provision of ships and various other facilities on behalf of the university community and the other Federal agencies involved. EM&R will have three main components and the Center. The first component is the Inland Waters Branch which is primarily concerned with the natural science and engineering aspects of water resources in Canada and will provide the Canadian representation on most of the IJC boards. The Branch will be represented at the Center by three of its main divisions. One of these is the Great Lakes Division, which is concerned with the physical, chemical, and geological aspects of the Great Lakes and other Canadian lakes. The initial research activities of this division will concentrate on the Great Lakes and will hopefully lead to techniques which can be used on other lakes throughout Canada. Another is the Water Quality Division, which has a major service function to undertake all of the water chemistry analyses of samples from the network of lakes across the country to provide the base line for water quality data. In addition, this division will conduct a certain amount of research on water treatment processes. The third of these divisions is the Hydraulics Division which is concerned with the major service function of calibrating all the current meters used for measuring steam flow and lake currents throughout Canada. The major part of the Hydraulic Division's facilities will be two long towing tanks for calibration purposes. In addition, there will be some hydraulics research facilities for sediment research and other experimentation and testing.

The second component of EM&R represented at the Center is the Policy and Planning Branch. The Policy and Planning Branch is the socio-economic wing of the water sector of EM&R. The Branch will be staffed by economists, sociologists, geographers, and planners who will be responsible for translating the technical knowledge gained by the other two branches into sound public policies, and will undertake research in these fields related to water resources.

The third component of EM&R is the Marine Sciences Branch. The function of the Marine Sciences Branch is to maintain and operate the ships for support of Great Lakes research.

There are other agencies in EM&R which will utilize the Center for certain aspects of their work concerned with the Great Lakes, particularly the Fisheries Research Board which is concerned with biological aspects of the Great Lakes and eutrophication processes and is closely related to the Great Lakes Division which undertakes physical, chemical, and geological studies. The National Health and Welfare Board is concerned with bacteriological and health aspects of pollution and works closely with the Water Quality Division on developing new waste treatment proces

Through the Association of Universities and Colleges of Canada, the universities are involved in the planning of the Center at a very early stage. The private sector is involved in undertaking contract research, especially in the instrumentation field and in carrying out some portions of the overall research effort.

An advisory committee is being formed to provide management guidance of the Canada Center for Inland Waters. The advisory committee will consist of approximately 4 Federal Government representatives, 7 university representatives, 4 provincial Government representatives, and 4 private sector representatives. The committee will participate in the planning of the Center. The provincial and Federal Representatives have the function of making sure that the research results which are generated at the Center are put into practice in the management of Canada's water resources.

In addition to research functions, the Center for Inland Waters has important service functions, such as the Water Quality Divisions monitoring program in the Great Lakes. There are also functions in connection with water resource management, such as working on the IJC pollution reference report. The close collaboration of the Center between monitoring and survey types of programs, the research groups (both university and government), and the management responsibilities will offer considerable advantage to conducting and utilizing the results of Great Lakes research.

The permanent buildings of the Center are being started this year at Burlington and will be completed in stages by 1972. The permanent buildings will contain office and laboratory facilities for university researchers. These offices and labs will be adjacent to the government scientists working in the same fields in order to promote better interchange and coordination. The 50 laboratory rooms will accommodate about 250 university researchers involved in Great Lakes research who will work out of the Center during various times requiring use of the facilities. Most of the time, they will be working at thier own universities.

The total capital cost of the Center for Inland Waters facilities is estimated to be $23 million. Presently, site development for the permanent buildings is under way. However, due to the urgency involved -- especially because of the pressure of the IJC report on pollution and remedial action for Lake Erie -- the work of the Center actually began late in 1967 out of a trailer complex. When the permanent buildings are available, the trailers will continue to serve a useful purpose as mobile laboratories for research work at different locations throughout Canada.

Research support.--With regard to support of university research in water resources, there are three ways in which universities may obtain funds. The first way is through contract research. In the current fiscal year, for example, the Center has $300,000 in contract funds which are made available to universities and the private sector for highly directed research in areas of priority need. The second source of financial support for university research is through grants-in-aid by the National Advisory Committee in Water Resources Research. This is a newly established committee and has been well budgeted. The Committee's grants-in-aid are of two kinds: (1) development grants to encourage the development of 4 or 5 interdisciplinary water resources research centers to provide a firm foundation from which they can work, not only in the Great Lakes Region, but also across the country; and (2) to support highly relevant projects in the universities which do not qualify for the large interdisciplinary development grants. These grants also take into account program priorities. The third level of support comes from the National Research Council whose funds are directed toward supporting the excellent researcher, regardless of purpose. For example, in the water resources field, the National Research Council contributed in 1966 about $600,000 towards undirected research.

<u>Coordination of research</u>.--The Great Lakes research activities of the provincial and Federal Governments and the universities are,in large part, coordinated in an informal manner through the Great Lakes Working Group of the Canadian Committee on Oceanography and,to a lesser extent, through the International Association for Great Lakes Research. The members of the Working Group provide, among other things, co-
ordination and modification of field programs, joint ship and research platform
through the Canadian Committee on Oceanography similar to the program forecasts pres
scheduling, information exchange and issues program forecasts issued by the U.S.
Army Corps of Engineers Lake Survey from Detroit.

The Canadian Government is attempting to make coordination through these groups more effective by providing assistance of the Center for Inland Waters. For instance for the first time, the Great Lakes Study Group sponsored a meeting in Burlington in October 1968 in which all the agencies which have ships and research platforms operating in the 1969 Great Lakes season, or which want to make use of ships or research platforms that might be operating, were invited to propose a schedule for these activities including coordination between Canadian and U.S. agencies.

The most significant contribution of the Great Lakes Working Group has been to relieve the universities of the responsibility of operating research vessels on the Great Lakes. The Canadian policy in this matter has been that while the universities in their research efforts should be able to direct the operations of larger research vessels, they should not be charged with the responsibility of their operation and maintenance. However, the universities do operate their own smaller research craft (e.g., less than 100 feet in length). The two Federal departments operating ships are the Department of Transportation and the Department of Energy, Mines, & Resources These Departments provide vessels larger than 100 feet either full time for the Great Lakes research activities (such as the Port Dauphine which is operated primarily for the University of Toronto) -- or part time (such as the Limnos which is operated under the Canada Center for Inland Waters and occasionally is used for governmental research work).

The Great Lakes Research Committee of the Canadian Committee on Oceanography is involved in oceanographic as well as water resources research since the Great Lakes are useful as a "model" ocean as well as providing for fresh water or limnological research. A coordinated program of research on the physical aspects of Lake Ontario is being planned for the International Field Year on the Great Lakes under the International Hydrological Decade Program. This program is expected to provide a great deal of needed information about the pattern of currents and the circulation of the lake as well as the thermal regime and the air-mass modifications over the lake which will aid in improving water resource management of the other Great Lakes. The program has suffered from budget inadequacies; still many researchers are hopeful that these problems can be overcome by the Canadian and U.S. Governments and the benefits of joint effort on the program realized.

Cooperation in international measures.--While Canada has taken significant steps towards organizing and coordinating its interests in Great Lakes research; it is necessary to evaluate the extent to which these arrangements are satisfactory for joint Canadian-U.S. coordination and to serve as a basis for setting up a basin-wide management regime. Because of the fewer Canadian agencies and jurisdictions involved with research and management activities in the Great Lakes, coordination was, until recently, accomplished through informal arrangements. However, with the establishment of the Center for Inland Waters, there is now a formal and fairly comprehensive research and policy body in Canada which is similar to the Great Lakes Basin Commission of the United States. Undoubtedly, the Center for Inland Waters and its parallel organization in the United States will facilitate cooperative U.S.-Canadian research efforts and buttress the traditional role of the IJC in adjudicatin Canadian-American interests in coastal zone resource utilization.

A valuable contribution which could be made by the Center for Inland Waters with respect to the Great Lakes and other national interests would be to further develop the basis for water policy for increased diversion of water from Canadian watersheds into the Great Lakes watersheds for:

(1) Reclaiming "downstream" for Canadian use with benefits accruing to the United States and Canada from interim use, such as lake level and flow regulation and pollution carriage and dilution, power generation, and navigation; and

(2) Purchase by and export to the United States, whereby waters may be subject to joint interim use as indicated above and then utilized by the United States, such as through power generation at Niagra or diversion to water-deficient areas of the United States.

A second significant Great Lakes policy question concerns the institutional arrangements necessary to coordinate and to integrate current operations and long-range planning, research, and decision-making activities of the United States and

Canada into a basin-wide management regime for the Great Lakes including Lake Erie and Lake Superior as discussed in Part I. For instance, the execution of a successful pollution prevention and restoration program for Lake Erie -- as seems likely to be recommended by the International Joint Commission in its study -- and the determination of a policy position on the "non-degradation" aspects of the preservation of water quality in Lake Superior will require the agreement upon priority measures and their application on a basin-wide basis, such as has been done on the cooperative attack on the sea lamprey by the jointly constituted Great Lakes Fisheries Commission. However, in this regard, it may not be desirable to form special-purpose international commissions such as the Great Lakes Fisheries Commission to respond to every basin-wide management problem such as pollution control, lake restoration, environmental monitoring, and the like. Rather, it would seem appropriate for these purposes to utilize the regional, basin-wide organizations with a comprehensive planning and coordinating responsibility, such as the Great Lakes Basin Commission and the Center for Inland Waters, neither of which were in existence when the Great Lakes Fisheries Commission was formed. Resource management issues needing arbitration or formulation of joint policies would be referred as before to the IJC for decision or ratification.

PART V

THE NEED FOR DIRECTION IN R&D IN THE MARINE SCIENCES FOR PROMOTING OPTIMUM USE OF THE COASTAL ZONE

The Need for Regional Objectives

Because of the complexity of the institutional and physical forces at play, the development of the technological knowledge and skills has become an increasingly important factor in the growth of the Great Lakes Region. The present level of development could not have been achieved without the application of a wide range of technical knowledge and skills, especially in the area of water resources development. However, it is equally true that the lack of innovation in certain areas of applied science and technology has allowed the evolution of major problems and degradation of these same resources. The interaction of the demands of intensive use with the natural and ecological relationships of the Great Lakes has created complex and difficult problems as discussed in the body of this report. Furthermore, as the continued growth and development of the region becomes more dependent on these resources, these problems will become more complex and difficult to solve in terms of adjusting man's activities to perpetuate the quality and quantity of the region's natural resources.

It is true that the development of a comprehensive plan for regional growth and development would be an effective tool to help achieve optimum use of the manpower, capital and natural resources of the Great Lakes Reion. However, the process of research and development (R&D) should be strengthened as an integral part of comprehensive regional planning and decision-making for establishing priorities for use, directing engineering and scientific studies, and reconciling local, national, and international interests. The provision of the information and knowledge of physical and social sciences, economic relationships, and institutional arrangements to enable the decision-making process to be conducted effectively will require an interdisciplinary approach to the investigation, research, and design of goals and specific actions for optimum utilization of unique opportunities and the avoidance of and solution to problems.

An observation derived from the preliminary review of the research indexes and other literature throughout this study is that there does not appear to be a clear relationship between the large amount of scientific research being conducted and the goals or directions for the continued growth of the Great Lakes Region, or the relative roles of the institutional arrangements in the continued growth of the Great Lakes Region. The reasons for this appear to be twofold.

First, as discussed in Part I, the notion of region-wide and national goals for the growth and development of the Great Lakes Region has not had time to emerge from the institutions whose scope of decision-making and activities influence, or are influenced by regional development trends and problems. On the other hand, specific opportunities and problems -- such as water quality -- throughout the Region are more susceptible to identification,and, consequently, can more readily be defined in terms of specific development actions or problem-solving R&D.

The second reason stems from the first. In the absence of lakewide, basinwide, or regionwide objectives -- except for after-the-fact problem crises such as the lamprey eel invasions or heavily polluted waters in the Great Lakes -- the "D" part of the R&D process has not been directed toward achieving pre-determined targets. In other words, in the absence of regional objectives, it has generally been difficult to define the value bench marks upon which to achieve a satisfactory determination as to what is "optimum", in order to apply R&D to developing the means to achieve optimum use. It should be made emphatically clear that if the Marine Sciences Council is to carry out its mandate to promote the optimum use of the coastal zone, whether refering to Lake Erie and Lake Superior or any other coastal zone region, the formulation of policy and programs to this end should be derived from clear-cut regional objectives developed jointly (on an intergovernmental basis) through a regional mechanism and approved by state and local governments which will need to implement action programs to achieve them. The alternative is to continue to use coastal zone measures in the marine sciences to react to crises on a local scale that challenge regional and, hence, national well-being such as the level of pollution developed in Lake Erie from "local sources" before adequate enforcement procedures were implemented.

While the principle of state rights and local responsibility are fundamental to the American system of government, the national interest has long been impaired by a piecemeal approach to solving problems of an inter-jurisdictional nature wherein parochial interests often play an overriding role. While the Great Lakes Basin Commission, the Great Lakes Compact Commission, and the several Council of Governments now operating in the Lake Erie Basin are increasing their coordination of regional affairs, accomplishments in regional programs is not keeping pace with the demand which growth in the coastal zone is placing on them. For instance, there is no agency or program functioning presently to adequately study the comprehensive transportation requirements for the Great Lakes Basin and to consider alternative plans for effectively initiating a supersonic air transport system. Should the SST development program continue, the airborne technology will likely be at hand considerably earlier than the construction of desirable air fields or terminals,rail and highway connectors, and other adjustments needed to effectively integrate the SST system into the regional growth pattern.

An additional element that appears to be lacking from these planning programs (some of which deal with R&D) is that of distinguishing the kinds of functions or problems which lend themselves to particular solutions and levels of government A specific example of this involves the issue of solid waste disposal. In terms of level of institutional responsibility, some of the research problems can clearly be handled on a "local" basis, such as certain localized land fill-land use aspects of solid waste disposal. Other aspects of this same problem -- such as the long-range impact of landfills on the lake ecology -- are clearly a regional or lake-wide concern. Even though the division of such a problem into its several jurisdictional relationships is a complicated task, the only way in which the entire governmental system under which we operate (local, state, Federal) may be brought to bear on these problems is to utilize the institutional mechanisms that are now available to enable the interests and capabilities of each component, or level of government to be expressed and weighed in the problem-solving and goal-formulation process.

The Need for Priority Assessment

This report has developed an extensive list of considerations and recommendations for measures -- including those in Appendix A -- for promoting optimum use of the coastal zone of Lake Erie and Lake Superior. While the recommendations on water quality control in Appendix A are listed in order of their priority importance based upon urgency of the problem, ten criteria have been identified below which relate to priority analysis for distilling from the recommendations in this report implications for implementation of, or advances in marine science and engineering, and which also serve as a basis for determining the allocation of resources (financial and technical) for these purposes. These criteria may be applied either individually or in combination and, under certain circumstances, may have overlapping implications. In general, the measure deserves a higher priority in accordance with the degree to which the following criteria are served:

(1) Relationship to use of coastal resources

The importance of the measure in achieving objectives for optimal use of the coastal zone.[1]

(2) Relationship to problem

Whether the measure focuses either on the marine science and engineering aspects of the most urgent effects of a problem or the most critical causes of a problem. (E.g., one can either breed new kinds of clams that are unaffected by pollution or remove the sources of pollution injurious to clams).

(3) Probability of success

The measure should have a reasonable chance of achieving successful results, although more risk can be tolerated for measures which hold promise of larger benefits relative to costs.

(4) Importance to related objectives

The measure should contribute, or be applicable to, progress and[2] information useful to the achievement of other related objectives.

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1 For example: (1) opportunity for multiple use, (2) compatibility of use of in-shore waters, (3) maintenance of options for future uses not foreclosed by degradation of resources (Marine Science Affairs, March 1968, p.63), and (4) other regional objectives related to the use of coastal resources, as described on pages I-44 through I-46.

2 For example, the measures for the enhancement of water quality may be of benefit to a variety of uses: power, flow regulation, flow augmentation, recreation, fish and wildlife, flood control, drainage, navigation, water supply (industrial, municipal, and agricultural), and waste holding, dilution, and transportation.

(5) Provision of key information

The extent to which the measure fulfills gaps and areas of inadequate information that are pivotal to key planning decisions, including R&D planning.

(6) Resource feasibility to implement measure

The measure should be feasible of accomplishment with present, or a realistic expansion of, facilities, manpower, and institutional (organizational) arrangements. (Additional requirements beyond existing capabilities should be clearly identified as part of the measure proposal.)

(7) Achievable within time limits

The measure should be achievable within reasonable time limits in keeping with short-range or long-range targets.

(8) Relationship of costs to available funds

The measure should be able to be accomplished within reasonable financial limits whether involving a single appropriation or commitment to a long-term funding schedule.

(9) Area of coverage

While the areal nature of a problem may be focused locally, remedial measures should be designed to serve regional benefits as well.

(10) Relationship of costs to benefits

Local, regional, state, national -- or international, if an international measure -- benefits should be favorable in relation to economic and social costs. Benefits include net economic gains but also certain social and other intangible benefits requiring substantive evaluation.

In addition, there are several alternative strategies for applying these priority measures in marine science and technology. These strategies are generally used in combination and include the following:

(1) The "most-urgent" strategy: This kind of strategy calls for attacking the most-urgent or gravest problem first. However, the most-urgent problem is often the most significant in scale, as well as requiring the largest amount of resources and time to solve.

(2) The "least-cost" strategy: Under this strategy, the problem requiring the least cost in resources to solve is attacked first. Because certain problems may cause increasingly greater economic loss and cost more to ameliorate if attacked later or over a longer period of time, the least-cost strategy seeks to curtail these problems first.

(3) The short-range strategy: This strategy involves attacking first the problems which can be solved immediately or within a short period of time with existing capabilities and constraints of time and funds. Short-range strategies are frequently stop-gap or temporary in nature if applied to large problems. Problems able to be effectively solved by short-range strategies are usually localized and offer limited lake-wide or region-wide benefits. Additionally, the cost of short-range strategies is usually proportionally greater than long-range strategy accomplishments because of the lack of economy of scale and reliance on less efficient technologies or hastily planned activities.

(4) Long-range strategy: Strategies of this sort involve an integrated plan for large and small problems allowing for longer periods of effort and more money to solve where necessary. The aggregate potential benefits are greatest in long-range strategies through the advantages in cost savings through being systematic and achieving economies of scale and being able to accommodate a wider range of benefits. Long-range strategies will usually require program and financial commitments overlapping several generations of decision-makers, such as chief executives or legislative bodies.

(5) Hedge strategy: This approach is used to offset the disadvantages which may result from changing from one of the above strategies to another. For example, if it should prove necessary to change from a long-range program to a short-range program, the idea of a hedge is to have completed first increment of the long-range program so as to have a workable system in that portion if the program should be curtailed. Another variant of the hedge strategy is to break a long-range strategy down into discreet investment stages which have a utility of their own but which can readily be expanded or modified to conform to a long-range plan for larger scale investments as funds and other resources become available, or as the need materializes. Either of these variants are accomplished by using a combination of long-range and short-range judgments in program timing. For example, a long-range program to solve the most-urgent problem may be hedged against possible change in strategy (e. g. due to change in priorities or unforeseen problems arising and pre-empting program funds) by attacking some of the "least-cost" and "short-range" programs initially in the long-range programs The main problem with the hedge strategy is that part of the advantages associated with longer range commitments are lost for shorter range security.

While a sense of priority for the recommendations in this report have been made on the basis of needs and objectives discussed in Part I and the areas of conflict or urgency discussed in subsequent Parts, it is beyond the level of effort for this study to execute the analysis required for the application of the above criteria and strategies to all of the recommendations. It is recommended that the Marine Sciences Council explore the possibility of establishing a priority review procedure based on the above criteria and strategies, perhaps on a pilot basis initially, to determine the extent to which it would be feasible to initiate such a review procedure on a regular annual basis.

APPENDIX A

SUMMARY OF WATER QUALITY CONTROL RECOMMENDATIONS

A Summary of Measures Recommended for the Prevention of Pollution and Restoration of the Great Lakes, with Special Attention to Lake Erie and Lake Superior, and Commentary on Selected Nutrient-Removal and Non-Nutrient Pollution Abatement Measures

For the purposes of this report, measures recommended for water pollution control have been divided into two major categories: preventative and restorative. Preventative measures are employed to remove nutrients before discharge into the lake or tributary and are oriented towards removing the causes of pollution and accelerated eutrophication. Restorative measures are used to remove the nutrients or the products of eutrophy from the lake. The recommendations made by the reports indicated in the key below were compiled in rank order according to the degree of impact of the pollution source on lake pollution, and were categorized under the following headings:

I. Preventative Measures

1. Recommendations for nutrient-removal measures
2. Recommendations for R&D for nutrient-removal measures
3. Recommendations for non-nutrient pollution abatement measures
4. Recommendations for R&D on non-nutrient pollution abatement measures
5. Recommendations for R&D for both nutrient and non-nutrient pollution abatement measures
6. Recommendations on pollution abatement standards
7. Recommendations for R&D in setting and controlling standards for pollution abatement

II. Restorative Measures

8. Recommendations for restoration measures
9. Recommendations for R&D in the restoration of Lake Erie

The key for the sources of recommended water pollution control measures is as follows:

LER-16 (Page Number): Lake Erie Report: A Plan for Water Pollution Control, Federal Water Pollution Control Administration, Great Lakes Region, Washington, D. C., August 1968.

GLR-42 (Page Number): Great Lakes Restoration, Review of Potentials, and Recommendations for Implementation, Pacific Northwest Laboratories, Battelle Memorial Institute, Richland, Washington, June 17, 1968.

FWS: Great Lakes Basin Comprehensive Framework Study, Plan of Study Document, (tentative unpublished draft) Great Lakes Basin Commission, Ann Arbor, Michigan, September 1968.

EAP: Early Action Program, Vol. 3, "Public Facilities and Services for Economic Development -- Lake Renewal and Management", Upper Great Lakes Regional Commission, Washington, D. C., March 1968.

Recommendations having no source identification were formulated by NPA. Comments have been made on selected nutrient-removal and non-nutrient pollution abatement measures (Preventative Measures, items 1, 2, and 3 above) by Dr. Robert A. Sweeney, consultant to the NPA Great Lakes Study Project. The commentaries were made along the lines of the following questions:

1. Completeness of list of recommended measures

   a. Is the list of recommended measures complete; or what, if any, important aspects of prevention or restoration have been omitted?

2. Deficiencies in R&D

   a. What is your assessment of the R&D needs that are not being realized in the overall problem of pollution prevention and restoration?

   b. Estimate what it would take to fill these particular needs in the most expeditious way.

3. Information for planning

   a. What major economic and technical information deficiencies can you identify that are associated with decisions involved in planning and implementing these measures, particularly the high-priority ones?

   b. What cost estimates (crude, if necessary) can you provide for making up the key technical information deficiencies, including basis or rationale for the estimates (e.g., use of similar information projects as a guideline, actual worked-out estimates on a factored basis)?

4. Facilities or equipment problems

   a. What are the likely deficiencies or bottlenecks in boats, laboratories equipment, instrumentation, or other facilities associated with the implementation of these measures?

   b. Identify the key facilities that are now available to implement the measures in whole, or in part.

5. Manpower bottlenecks

   a. What are the likely deficiencies in carrying out these measures in terms of the available quality and quantity of scientists, engineers, and technicians?

   b. How can these dificiencies be eliminated?

6. Sequencing problems

   a. What magnitude of time is likely to be required in implementing the measures primarily because of the need to perform certain key tasks sequentially in solving the problems of pollution prevention and lake restoration?

   b. Can you identify what kinds of R&D or other measures should be done first to facilitate subsequent R&D or execution of other measures so as to reduce overall time and costs, or to enlarge the benefits?

7. Excessive costs

   a. Which measures are likely to lead to excessive costs and, hence, major deficiencies in funding support?

   b. Which measures seem likely to pose little, if any, funding problem?

8. Penalties of postponement

   a. What are the most significant penalties likely to be incurred (either in market values or social values) if the implementation of these measures is postponed, say, 5 years?

   b. What key "opportunities" are being lost? (Relate to specific measures, where possible; and estimate the magnitude of these penalties.)

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I. PREVENTATIVE MEASURES

1. RECOMMENDATIONS FOR NUTRIENT-REMOVAL MEASURES

1.1. The maximum removal of nutrients from municipal waste water (GLR-41) using the following methods:

A. Primary, secondary, and tertiary treatments of waste water where needed for the removal of phosphates and other growth promoters.

B. Conventional septic tank-tile fields disposal systems in suitable areas (EAP).

C. Installation of suitable artificial absorption fields in combination with septic tanks in areas where minor limitations could thereby be corrected (EAP).

D. Use of holding tanks which are pumped as required in combination with waste treatment and disposal at a central facility (EAP).

E. Use of a conventional sewerage system in combination with central treatment facilities (EAP).

F. Use of an in-lake plastic pipe collection system in combination with central sewerage treatment facility (EAP).

G. Disposal of treated effluents by crop and forest irrigation or water spreading where suitable conditions exist (EAP).

H. Use of dried sludge disposal methods (EAP).

COMMENTARY

Completeness of List: 1.1.A. - H.

The use of algae to remove nutrients from municipal waste water was omitted from the list. One such technique being studied at the Water Resources Center of The Ohio State University under the direction of Dr. George Hanna, appears to be effective.[1]

Further R&D is needed to find uses for the algae such as for protein and vitamin supplements.[2] This could promote a better

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[1] Hanna, G. By Personal Communication, 1968.

[2] Mackenthun, K. M., and W. M. Ingram, Algal Growth Aqueous Factors Other Than Nitrogen and Phosphorous, FWPCA Publication # WP-24, 1966, p. 41.

cost-benefit ratio, one of the major deficiencies of tertiary treatment. Likewise, additional economic research is necessary to ascertain the costs of implementing the above, as well as other tertiary treatment processes (i.e., electrodialysis, distillation-absorption, etc.).[1]

Deficiencies in R&D: 1.1.F.

The use of an in-lake plastic pipe collection system was suggested in 1966 by Representative Barker B. Conable, who received by idea from a constituent.[2] While the technology for the construction and installation of such sewage lines exist, the major R&D deficiencies involve the design and effectiveness of sewage treatment facilities.[3] These exist whether the plant is located in the lake or on the shore. Without the development of more effluent techniques for removing nutrients, locating treatment facilities in the lakes would afford no great advantage. The "hedge strategy" should be applied until more efficient sewage treatment methods are available.

Facilities or Equipment Problems: 1.1.F.

The technology for the construction and installation of such pipe currently is available. For the most part, these were developed by the oil and gas industries.

Most in-lake construction problems have been solved by the United States Army Corps of Engineers. The Corps either has or

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1 Koenig, L., Studies Relating to Market Projections for Advanced Waste Treatment, FWPCA Publication # WP-20-AWTR-17, 1966, p. 72.

2 Faxlanger, W.F., Unpublished, letter of August 6, 1966 to B.B. Conable, p. 2.

3 Summary Report - Advanced Waste Treatment. FWPCA Publication #WP-20-AWTR-19,1968,

can identify the firms with the equipment and personnel to handle such tasks.

Excessive Costs: 1.1.F.

Considerable expenditures probably would be required to install pipes where they would not hinder and/or be damaged by commercial and recreation craft as well as dredging operations (by the Corps) to keep waterways open. These activities are heaviest in and around major lakeside municipalities, from which the largest amount of sewage is generated. Hence, it is advisable to construct such in-lak pipes and facilities away from the cities. This distance would add to construction and operation costs.

Though central treatment plants generally are more economical, there are instances where pumping costs for an extensive, dendritic collection system could become prohibitive. This would be the case if such pipes had to be depressed below the lake sediment. Therefore, the central treatment facilities could be located at a higher level than the major arteries of the collection system. If this were the case, flow augmentation would be necessary. In the Erie Basin, where the plain is fairly level with little slope towards the lake, the flow by gravity would not provide sufficient head to raise the wastes any appreciable distance.

Penalties of Postponement: 1.1.F.

Delays in the contruction of an in-lake collection system, coupled with the growth of population and increased shoreline utilization, could result in a decrease in area in which pipelines could be constructed. However, to couple such a collection system to an inefficient waste treatment plant would be illogical. Therefore, a postponement is recommended.

1.2. Improvement of land management practices in order to minimize the amount of nutrients flowing to the lakes as silt or agricultural run-off (GLR-41) including:

A. Programs begun or accelerated by state and federal agricultural agencies to control sediment loss, oxygen-demanding substances, and fertilizing agents from animal feed lots and farmland run-off (LER-16).

1.3. Maximum amounts of combined storm drainage should be conveyed to secondary treatment plants (GLR-41) including:

A. Separation of storm and sanitary sewage in all new sewerage systems.

B. Programs begun or accelerated by the five Lake Erie Basin states to devise methods to deal with the problems of storm and combined sewer overflows. By 1980, all cities should have eliminated pollution (including nutrients) caused by urban run-off and combined sewer overflows. All outlets to surface waters should then be disinfected and directed away from recreational areas (LER-14).

1.4. The disposal of dredgings, garbage, trash, and refuse to the lakes should cease (GLR-41) including:

A. Disposal of dredged materials by:

1) Ponding and settling as an intermediate step prior to disposal of the carriage water, along with drying and consolidating of the dredged solids (EAP).

2) Disposal of carriage water on crop lands and forest lands (EAP).

3) Disposal of conditioned solids as land fill or soil conditioner (EAP).

B. The Corps of Engineers should find suitable methods of disposal of polluted harbor dredging spoils other than open lake dumping (LER-16).

COMMENTARY

Deficiencies in R&D: 1.4.B.

There has not been extensive investigations on the nature of the harbor sediments transported by the Corps to ascertain the quantity and quality of the polluted materials. Some studies that have been conducted, by such agencies as the Great Lakes Laboratory of the State University College at Buffalo and the Center for Great Lakes Studies of the University of Wisconsin at Milwaukee,[1] demonstrated considerable variations in the physical and chemical characteristics of the sediment, not only among the eight harbors investigated, but within harbors.

In addition, it has been reported that former Corps dump sites are supporting larger populations of fish than similar areas that did not receive dredged materials. In fact, these dump sites are sought out by fishermen.[2]

Hence, additional research is necessary on the nature, extent, and effects of materials dredged from the harbors of the Great Lakes. Such studies could be handled through contracts with private and academic agencies who already have the presonnel, equipment, and knowledge to handle such tasks.

As for those materials that are either "too" toxic and/or high in nutrients to be deposited in the lakes, several disposal methods currently are being examined. The most economical appears to be

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1 "Investigation of Treatability and Effect on Biota of Dredged Materaisl from Selected Great Lakes Harbors", Report from Corps of Engineers Contract# DACW49-68-C-0[illegible] with University of Wisconsin at Milwaukee, 1968.

2 Sweeney, R. A., Reports (7) on some of the effects of slag deposition on fisheries of Eastern Lake Erie, Report from Bethlehem Steel Contract# 21-6009-A with State University College at Buffalo, 1969.

depositing the material behind slag dikes within the harbor. It has been proposed that such areas could be utilized eventually for parks, industrial sites, etc. However, since none of the areas have been completely filled, their value cannot be determined. Hence, two to three additional years research will be required. (The continuation of these investigations currently is in jeopardy due to proposed cuts in the Federal budget.)

Information for Planning: 1.4.B.

Initial funding for the above studies amounted to $5,500,000; most of which went for pilot dikes. Additional funds have been requested to complete the research. If the supplement is authorized, it should be sufficient to finish the comprehensive investigations.[1]

Facilities or Equipment Problems: 1.4.B.

If money is available, the facilities, equipment, and personnel are available to gather and analyze the necessary data.

The University of Minnesota at Duluth and the State University College at Buffalo are equipped to carry out such research on Lakes Superior and Erie, respectively. The University of Wisconsin at Milwaukee and the University of Michigan could contribute to these investigations if given assistance in sampling.

It does not appear that the FWPCA's Cleveland, Duluth, and/or Chicago offices have sufficient manpower and equipment to conduct

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1 Tarbox, Gen. R. M., Statement to the Four-State Enforcement Conference on Lake Michigan Pollution, Chicago, Illinois, 1969.

these investigations.[1]

Manpower Bottlenecks: 1.4.B.

The lack of qualified technicians appears to be a problem for both private and governmental agencies. Academic institutions are able to supplement these deficiencies with students, most of whom will become engineers or senior scientists if they remain in the aquatic fields of endeavor.

The need for additional support personnel is a national problem. By 1972, it has been estimated that we will need 225 percent (23,213 individuals) more water pollution technicians than the number in 1967 (10,267 individuals).[2]

It was hoped that such programs as the Sea Grant Act and the training programs of the Federal Water Pollution Control Program would generate technicians for the Great Lakes research. However, neither of these programs have received sufficient fiscal support to remedy the problem due to other priorities.

Sequencing Problems: 1.4.B.

Approximately two years of additional data from sediment analyses and pilot dike (land-fill) studies will be necessary before a sound decision can be made as to what material should or should not be dumped in the open lake. Through such research, it may be found that some of the dredgings are not detrimental. Therefore, these

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[1] Posten, W.. By Personal Communication, 1968. (Note: Dr. Posten is the Director of the FWPCA's Great Lakes Regional Office in Chicago.)

[2] "Junior Colleges Enter Pollution Manpower Picture", Environmental Science and Technology, Vol. 2, No. 5, 1968, pp. 328-329.

could continue to be put into the lake, the least expensive disposal technique. This also could decrease the space needed for on-shore deposition.

Through the pilot dike projects, more cost/benefit data is being generated on which a sounder decision for subsequent disposal techniques can be formulated.

Excessive Costs: 1.4.B.

To ignore the above could result in a considerable waste of both time and funds. It is both more expensive and time consuming to empty a dredge or barge onto shore than to dump such material in the lake. For example, it costs ten times as much per cubic yard to pump dredged material ashore in Buffalo than to put it in Lake Erie.[1] Likewise, dikes used to contain dredgings are expensive. For example, the construction of the 2,000 linear foot limestone dike with 360,000 cubic yards of limestone in Buffalo cost over $480,000. If the dike could be used for a longer period fo time by continuing to put less harmful wastes in the lake, this would mean a considerable saving.

Penalties of Postponement: 1.4.B.

Enforcement of the blanket statement that all harbor dredgings should not be put in the open lake should be postponed until the areas of polluted sediment have been identified. Likewise, the pilot dike studies should be continued to determine which alternate method of disposal is most economical and effective. The time and

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1 Wright, Col. A. By Personal Communication, 1969. (Note: Col. Wright was the former district engineer in Buffalo for the Corps).

funds necessary to complete these studies far outweigh the chance that some polluted sediment may continue to be put in the lakes.

1.5. Fish management as a means of removing nutrients or enhancing fishery of a lake (EAP) should be carried out to the extent practical including:

A. Removal of rough fish, particularly alewives (GLR-41).

B. Harvest of desirable fish, preferably by game and commercial fishing to the extent that nutrient removal is optimized and propagation is sustained (GLR-41).

COMMENTARY

Completeness of List: 1.1.5.

One measure that was omitted was the stocking of the lake with desirable game fish that are tolerant of present environmental conditions. (Restoration of the Lake Erie fisheries was recommended in LER-16). One such fish that has been highly successful in Lake Michigan is the coho salmon (*Oncorhynchus kisutch*). This ~~organism~~ fish matures rapidly, is "exciting" to catch, and may provide a check on the rough fish populations.

The coho stocking program has been highly successful in Lake Michigan[1] resulting in the rejuvenation of the sports fishery in that lake. This has prompted the formulation of a cooperative stocking program in 1968 among New York, Ohio, and Pennsylvania.[2]

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[1] Tody, W. H., "Introducing the Coho", *Limnos*, Vol. 1., No. 1., 1968, pp. 17-20.

[2] Pearce, W. A., *Status of Coho Salmon in New York State*, Report by the New York State Conservation Department, 1968, p. 4.

The impact of the latter cannot be evaluated fully until 1970.

More R&D is needed to develop other species of fish with the above characteristics. In addition, more sites and better techniques for stocking the lake should be introduced.

Deficiencies in R&D: 1.1.5.A.

There is little necessity for R&D on techniques for harvesting the so-called rough or trash fish (i.e., alewives - Alosa pseudoharengus, carp - Cyprinus carpio, and sheepshead or drum -- Aplodinotus grunniens). Essentially, the same methods can be utilized that were employed in the gathering of the so-called desirable fish (i.e., whitefish -- Coregonus clupeoformis, blue pike - Stizostedion glaucum, and yellow pike or walleye - Stizostedion vitreum vitreum.

Currently, there is an excess of both manpower and equipment since the Lake Erie fisheries from both Canadian and American ports are rapidly declining. For example, the blue pike commercial catch decreased from 20,000,000 pounds in 1956 to 79,000 in 1959 to practically nothing at all since then.[1]

The major problem regarding the gathering of trash fish is utilization. Some have been used for cat and mink food. However, this is a small market.

One use that has been suggested for these organisms is that they be processed into fish protein concentrate (FPC) or fish flour.[2]

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1 Robertson, A., "What is Happening to our Great Lakes", Limnos, Vol. 2, No. 1, 1969, pp. 12-17.

2 Sweeney, R. A., "Lake Erie -- The Lively Corpse", Conservation in Focus, Vol. 2, No. 1., 1969, pp. 6-7.

Significant legal and technological problems concerning FPC have been solved recently.[1,2] To date, R&D on FPC has been limited to marine fish. Investigations are needed on the processing of trash fish from the Great Lakes into fish flour. If this research is successful, such an industry could contribute to the lessening of the world's protein shortage while assisting in the removal of nutrients from the lake and revitalizing the sagging fishery industry.

Information for Planning: 1.1.5.A.

The techniques and economics of processing marine fish into FPC already have been determined through R&D at pilot plants sponsored by the Bureau of Commercial Fisheries at Texas A&M University, College Station, Texas and the University of Maryland, College Park, Maryland.[3] However, no information is available on the usefulness of fresh water fish in such a process.

A pilot plant should be constructed on or near Lake Erie. The A&M plant cost $150,000 to construct. An additional $100,000 would be needed for staff and supplies for a two-year investigation. If successful, some of the costs could be recaptured through the sale of the hardware to private industry.

Facilities or Equipment Problems: 1.1.5.A.

Institutions with sufficient competence to operate a FPC pilot plant on or near Lake Erie include State University of New York

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1 Nunn, R.R., "Fish Protein Concentrate Production is on the Rise", Ocean Industry, Vol. 3, No. 11, 1968, pp. 47-50.

2 Ocean Industry, Vol. 4, No. 1, 1969, pp. 36-40.

3 Nunn, Ibid

Water Resources Center at Syracuse, Cornell University, The Ohio State University, and the University of Michigan.

Private industry, such as Pillsbury, General Mills, and the National Biscuit Company, also might be interested in such a study.

A consortium of an industry and academic institution, such as occurred at Texas A&M could reduce costs.[1]

Penalties of Postponement: 1.1.5.

(1.1.5.A.) With the rapid decline in commercial fisheries on Lake Erie, more fishermen are seeking employment in other occupations Likewise, few, if any, new individuals are learning the skills of commercial fisheries. The longer the delay in the revitalization of this industry, the less trained individuals will be available.

Likewise, the longer the present fishing fleets and equipment remain unused, the greater the refurnishing and rehabilitating costs.

(1.1.5.B.) There is significant evidence that the populations of the present game and commercial fish in Lake Erie, with the exception of yellow perch (*Perca favescens*) are declining rapidly.[2] Any program to promote the harvesting of these organisms would contribute to the problem rather than the solution.

1.6. Wastes from watercraft should be treated to the equivalent of secondary treatment (GLR-41).

COMMENTARY

Deficiencies in R&D: 1.6.

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[1] Ibid..

[2] Robertson, A., op. cit..

There has been a fair amount of research on the treatment of wastes aboard watercraft.[1,2] In addition, much of the R&D conducted on house and camper trailers can be applied.

The major problem appears to be getting the states and provinces to agree on what treatment method(s) is acceptable. This problem is created by the frequent movement of craft across state, provincial, and international boundaries.[3,4] R&D on mechanisms (political) to arbitrate such legislation is needed.

Penalties of Postponement: 1.6.

Failure to devise an acceptable treatment system will result in the postponement of the installation of pollution abatement equipment. This already has occurred in New York State.[5]

While the effluent from pleasure craft is small when contrasted to the amounts generated by major cities and factories, within restricted areas, their effects may be considerable. For example, the coliform count in Put-In-Bay Harbor (Ohio) increases up to one thousand fold over the July 4 weekend. As a result, swimming may be banned when the demand for this form of recreation is highest.

The failure of governmental agencies to reach an accord on treatment facilities for boats have led some manufacturers to omit

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1 Clark, B.D., Houseboat Waste Methods for Collection and Treatment, Pacific Laboratory, FWPCA, Corvallis, Oregon, 1967, p. 82.

2 Dugan, P.R., Evaluation of Marine Toilet Chlorinator Units, New York State Research Report #9, 1962, p. 58.

3 "Boat Sanitation Laws Summarized", Limnos, Vol. 2, No. 1, 1969, p. 26.

4 Legislative Ledger, The Outboard Boating Club of America, Vol. 16, No.3, 1969, p.5

5 Ibid..

toilets in their 1968-69 models. Owners of such craft are forced to solve the waste treatment and/or disposal problems.

The indecision also is discouraging private industry from conducting its own R&D on treatment methods and hardware.

1.7. Regulation of lake levels and flows for dilution and transport of waste materials (to the ocean) should be optimized in conjunction with other interests in regulating lake levels and flows including:

A. Development of additional sources of water supply to a lake to decrease detention time or manipulate water temperatures to reduce nutrient buildups or aquatic plant productivity (EAP).

B. Extension of sewage treatment discharge pipes extended distances from shore to deeper and less nutrient-rich waters.

C. Timing of waste disposal according to atmospheric or river surge conditions.

D. The use of dredging techniques to establish greater depths and increase flows and circulation to provide dilution of nutrient and other pollutant buildups, especially in conjunction with other dredging purposes such as navigation and selective removal of materials for bottom restoration (EAP).

COMMENTARY (1.1.7.A. - D.)

Each of these suggestions are largely unsound. The only sources of water to dilute the Great Lakes are in Canada. The Canadians are all too aware of the worth of their aquatic resources and of the fact that most of their economy is controlled by foreigners, particularly Americans. The people and their governmental representatives do not desire to develop additional programs that would tighten these economic binds. All suggestions by the United States that water should be brought down from the North have (thus far) met with concerted opposition. (However, this does not preclude the possibility of negotiating water resources matters within the context of broader U.S. and Canadian interests in bilateral agreements.)

Even if such water were introduced, it would have relatively little effect on the annual heat budget of either Lake Erie or Superior. Superior is too vast (1.22×10^{16} liters) to be affected in regard to changes in temperature and retention time.[1] Lake Erie, which is relatively shallow, has such an enormous surface area to volume ($25,745\ km^2/458\ km^3$) that the effect on the summer temperature would be negligible.[2] Even if a decrease in the average temperature of Lake Erie was possible, the ecological amplitude with regard to temperature of most of the algae (i.e., blue-green and Cladophora) that are causing the problems is such that their overall reduction probably would be negligible.

Decreasing the retention time and increasing the circulation in Lake Erie would be of little value if the quantity of pollutants being added to the lake were not reduced. The consequences of the former without the latter would be most detrimental to Lake Ontario, whose dissolved mineral content currently is increasing at the rate of 9.6 ppm per decade.[3] Hence, we must avoid passing the nutrient "buck" from Erie to Ontario.

The discharging of sewage wastes into deeper waters, particularly those of Erie, would compound our problems. It is a fallacy to believe that the deeper waters in Lake Erie are less nutrient-rich.

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[1] Wood, K.G., "Pollution and Lake Erie", Bios, Vol. 34, No. 3, 1968, pp. 103-110.

[2] Windchester, J.W., "Pollution Pathways in the Great Lakes", Limnos, Vol. 2, No. 1, 1969, pp. 20-24.

[3] Weiler, R.R., and Chawla, V.K., "The Chemical Composition of Lake Erie", Proceedings of the 11th Conference on Great Lakes Research, 1969, pp. 593-608.

Quite the contrary, the lake appears to be homogenous.[1] In addition, the biochemical and chemical oxygen demands (BOD and COD) most likely would increase the area and the duration of low oxygen that have been observed during the summer near or at the bottom of Lake Erie.[2]

The quantity and duration of the average, maximum, and minimum rates of flow of each of the United States tributaries of Lake Erie indicate that these streams and rivers are not sufficient to accept and digest any appreciable amount of the wastes generated by the towns and factories along their shores.[3] In other words, the quantity of wastes that would need to be stored would exceed capacity of the tributaries to absorb the pollutants.

Hence, suggestion 1.1.7.C. is impractical.

Dredging a tributary decreases flow. In fact, many of the problems concerning Lake Erie tributaries, such as the Buffalo and Cuyahoga, have been caused by the fact that they were enlarged to permit shipping.[4] Therefore, the same amount of water flowed through a wider channel. This decreased the speed and,subsequently, the digestive capacity of the rivers.

Another fallacy of 1.1.7.D. is in failing to recognize that dilution is seldom a solution to pollution. The most effective measures to correct such situations are to keep the toxic and nutrient materials out of the tributaries and lakes.

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1 Ibid..

2 Carr, J.F., Dissolved Oxygen in Lake Erie, Past and Present, Great Lakes Research Division Publication# 9, 1962, pp. 1-14.

3 Lake Erie Environmental Summary - 1963-64, FWPCA, 1968, p. 170.

4 Sweeney, R. "Rejuvenation of the Buffalo River" - Unpublished reports on findings from an investigation sponsored by the Allied Chemical Company, 1969.

2. RECOMMENDATIONS FOR R&D FOR NUTRIENT-REMOVAL MEASURES

2.1. Control of nutrient input to Lake Erie through better treatment methods, reduction of nutrient input in agricultural run-off, and development of a suitable product solution for phosphorous contained in detergents (LER-16).

2.2. Research is needed into the key mechanisms of eutrophication process and aging of the lakes (LER-16) including:

A. Factors influencing eutrophication process.

B. Factors influencing algal growth rates.

C. Effects of algal growth.

D. Development of control techniques including:

1) Physical removal of algae and its disposal as waste.

2) Commercial utilization of harvest algae.

3) Use of chemical herbicides to control algae.

4) Reduction of pollutant nutrients.

5) Dredging and hydraulic flushing techniques to remove bottom sediments containing decomposed algae and nutrients and to increase depth of water near shore.

6) Biological control measures.

2.3. R&D on more cost-effective and control (LER-16) methods of reducing pollution for ships or recreational boating waste disposal.

COMMENTARY

Deficiencies in R&D: 2.2.A.

The factors influencing the process(es) of eutrophication[1]

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1 Stewart, K, and Rohlich, G., Eutrophication -- A Review, California Water Resources, Record Publication# 34, 1967, p. 180.

and the Great Lakes[1,2,3,4] have been investigated for a number of years. Each of these reports has been somewhat lacking because there has not been many comprehensive (chemical, biological, and physical) studies conducted on Lake Erie. For the most part, studies have been concerned with a limited group of organisms, such as plankton, or chemical parameter, such as carbonates.[5] In order to understand eutrophication, one must examine the "entire picture". Few facilities, either academic or governmental, have the finances, equipment, and/or staff to conduct such a broad study over a period of several years. Probably only the investigations by the FWPCA[6] and the Great Lakes Institute[7] have come the closest to such a broad survey. However, those studies also have been deficient.

While it is not possible to re-do the studies that have been done in the past, we are able to use these data to identify our information gaps. Once this has been accomplished, a coordinated plan of

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1 Beeton, A.M., "Eutrophication of the St. Lawrence", Great Lakes Limnology and Oceanography, Vol. 10, No. 2, 1965, pp. 240-254.

2 Indices of Great Lakes Eutrophication, Great Lakes Research Division Publication# 15, 1966, pp. 1-8.

3 Davis, C.C., "Evidence for the Eutrophication of Lake Erie from Phytoplankton Records", Limnology and Oceanography, Vol.9, No.3, 1964, pp. 275-283.

4 Powers, C.F., and Robertson, A., "The Aging Great Lakes", Scientific American, Vol. 215, No. 5, 1966, pp. 94-104.

5 Sweeney, R.A.(ed.), In Press. "Changes in the Biology of Lakes Erie and Ontario", Buffalo Museum of Science.

6 Lake Erie Environmental Summary -- 1963-64, FWPCA, 1968, p. 170.

7 Great Lakes Institute Data Records -- 1963 Survey, Part I, Lakes Ontario, Erie, and St. Clair; Great Lakes Institute, University of Toronto, PR-23,1965, p. 195.

study, such as the one proposed by the Great Lakes Basin Commission[1], involving a variety of expertise should be formulated and initiated. If the finding is available, the cooperation and participation of both private and public agencies can be mustered.

The Joint Industry/Government Task Force on Eutrophication is an example of an effort that may contribute to the understanding and solution to the problem.[2]

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[1] Great Lakes Basin Commission Comprehensive Framework Study, op. cit., p. 317.

[2] Bueltman, C. G. "Progress Toward Limiting Eutrophecation", address before the 15th Annual Conservation Conference of the National Wildlife Federation, Washington, D. C., 1968.

Information for Planning: 2.2.A.-D.

To plan and carry out a comprehensive survey, involving hydrological, geological, chemical, socio-economic and biological studies on Lake Erie would require about $ 1 million. This figure was derived from the budget of Great Lakes Basin Commission's plan of study for the entire Great Lakes area.[1]

Facilities and Equipment Problems: 2.2.A.-D

One of the major difficulties that has retarded comprehensive surveys by American agencies has been the lack of ships or ship-time for extended cruises. (The Canadians solved the problem by assigning the Department of Transportation to provide and maintain craft for research on the Great Lakes). Academic institutions that have operated their own vessels, such as the University of Michigan, have found the costs and administrative time to be burdensome.[2]

While the U.S. Coast Guard does provide ship-time, researchers have little control over the duration and/or route of such cruises. Likewise the Coast Guard vessels are neither equipped nor designed for limnological research. To eliminate this problem one or more ships, such as the Limnos, should be assigned for duty in the Great Lakes.

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[1] Ibid.

[2] Chandler, D., by personnel communication, 1968. (Note: Dr. Chandler is the Director of the Great Lakes Research Division of the University of Michigan.)

Current shore facilities, such as those operated by the State University of New York, University of Michigan, and University of Wisconsin at Milwaukee, are adequate. The Ohio State University and University of Minnesota lakeside physical plants are being improved.

Most of the governmental laboratories currently have some equipment and/or manpower problems. Hopefully these will be remedied when governmental commitments abroad are reduced.

Manpower bottlenecks: 2.2.A.-D.

There appears to be a sufficient number of senior scientists and engineers for the jobs opening that are available. (This may not be the case if additional governmental funds are made available for the reasons stated in 2.2.A.4.) However, there is a need for additional technicians.

Sequencing problems: 2.2.A.-D.

While some measures, such as removing nutrients from domestic and industrial wastes, can and are being taken to retard eutrophication, major projects (i.e. dredging of the bottom of Lake Erie or prohibiting the open-lake dumping of the harbor dredgings) should not be made until after a comprehensive study is completed. Failure to do so could result in unnecessary expenditures and/or ineffective legislation.

Deficiencies in R & D: 2.2.B.

Most studies involving algal growth rates and eutrophication have concerned phosphates. Such investigations stem either directly or indirectly from the research of those who found phophorus to be the limiting factor in the development of algae within certain Connecticut lakes[1,2]. In other words, all the other factors, both chemical and physical, were acceptable for the growth of these plants with the exception of phosphorus, which was present in extremely low quantities. When more phosphorus was added, the algae increased proportionally. It has been proposed that phosphorus is the limiting factor with regards to algae growth in Lake Erie.[3] Yet it has been demonstrated that phosphorus may not be the sole controlling and/or limiting factor.[4] Vitamins, chelating agents and iron have been shown to be of equal or greater importance in other natural environments.[5] Hence, more research should be spent both in the field and the laboratory to ascertain if any other factor(s) are as critical as phosphorus in the limiting of algae growth in Lake Erie.

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[1] Hutchinson,G.E., "Limnological Studies in Connecticut, Critical Examination of the supposed Relationship Between Phytoplankton Periodicity and Chemical Changes in Lake Waters," Ecology, Vol. 25, 1944, pp. 3-26.

[2] Hutchinson,G.E. and V.T. Bowen, "A Direct Demonstration of Phosphorus Cycle in a Small Lake." Proceedings of the National Academy of Science. 33: 148-153. Vol. 33, 1948, pp. 148-153.

[3] Tazwell, C.M., Conference in the Matter of Pollution of Lake Erie and Its Tributaries. Cleveland, Ohio. U.S. Department of Health, Education and Welfare, Washington, D.C., 1966.

[4] Mackenthun, K.M. and WM Ingram, Algal Growth Factors Other than Nitrogen and Phosphorus, FWPCA, Washington, D.C., 1966, p. 41.

[5] Ryther, J., by personnel communication, 1968. (Dr. Ryther is the Director of Biology at the Marine Biological Laboratory in Woods Hole, Massachusetts.)

Such investigations could be promoted through such granting agencies as the National Science Foundation and/or Federal Water Pollution Control Administration, as well as through in-house research by governmental agencies. These investigations could be conducted for approximately $250,000 per year. This would cover the salaries of three or more senior staff and their supplies, assistants, overhead, etc. for a two year study. This is a small sum when contrasted with the amounts proposed for the removal of phosphorus from wastes through tertiary treatment.

Facilities or equipment: 2.2.B

There are sufficient, well equipped government laboratories (FWPCA's Duluth and Cincinnati labs) and academic institutions (Ohio State University, University of Michigan, Cornell University) where such studies could be carried out.

Deficiencies in R & D: 2.2.C

Most of the effect of algal growth related to pollution, including the fouling of beaches, boats and water supplies, have been and are being investigated. Several problems remain, such as the factors that trigger the detachment of *Cladophora* - an algae that has caused beaches to close when it washes ashore and decays.[1]

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[1] Water-Oriented Outdoor Recreation in Lake Erie Basin, op. cit.

Currently there appears to be sufficient personnel in academic and governmental facilities and funds (through the National Institute of Health, Federal Water Pollution Control Administration and Office of Naval Research) to conduct this research. The people involved in these studies appear to know through personal contact and science information exchanges (i.e., Smithsonian) who is doing what. Therefore, there is no need to develop mechanisms to structure or coordinate this research.

Facilities or equipment problems: 2.2.C.

Aside from the various regional offices of the FWPCA, competent algal specialists are located at Central Michigan College, Ohio State University, State University of New York, Syracuse University, University of Michigan, University of Minnesota and the University of Wisconsin.

Deficiencies in R & D: 2.2.D.1.-2.

Lakeside dwellers have begun to pool their resources to remove the algae along their beaches. This has encouraged the formation of a number of private companies and the development of hardware for the harvesting and disposal of algae, particularly Cladophora and other attached forms. Hence, there does not appear to be a need for the government to promote activity in this area.

To date only the marine algae have been commercially utilized.[1,2] Freshwater algae possibly can be utilized as a source of vitamins, proteins, drugs and mulch. R & D is needed on the chemical composition of these plants and the variations in these components with the seasons. Such research could be conducted at governmental laboratories and encouraged through the various granting agencies. Those who have had experience with marine algae, such as the investigators at Lamont Laboratory of Columbia University, should be encouraged to look into the freshwater area.

If these investigations indicate that a potential product, the small pilot plants should be encouraged. Perhaps these could be co-financed by industry and an academic institution.

Information for Planning: 2.2.D.1.-2.

Most likely $100-150 thousand per year over a three period would support a reasonable research effort at private and academically affiliated laboratories on algae utilization. A similar amount should be spent for in-house research. If drug and food companies could be interested in supporting such efforts, without getting into the problem of priviledged data, this could reduce the level of federal funding.

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[1] Taft, C.E., Water and Algae - World Problems, Educational Publishers, St. Louis, Missouri, 1965.

[2] Scholes, W.A., "Harvesting Seaweed Off Australis," Ocean Industry. 4(3): 69-70. Vol. 4, No.3, 1969, pp. 69-70.

3. RECOMMENDATIONS FOR NON-NUTRIENT POLLUTION ABATEMENT MEASURES

3.1. A minimum of secondary treatment should be provided by municipalities discharging waste water to the Great Lakes (GLR-32) including:

A. Treatment should be efficient and continuous and should provide for 90% removal of oxygen-consuming wastes. Limits should be recommended for specific pollutants such as suspended solids, settleable solids, ammonia, phenolics, oil, and those exerting a biochemical oxygen demand. These limits should be set at a level commensurate with their ability to interfere with the beneficial uses of water (GLR-32).

B. Whenever possible, treatable industrial wastes should be accommodated by municipal waste water treatment systems; and master plans for integrated treatment facilities in urban areas should be formulated. Areas with septic tank disposal systems should be incorporated into sewerage systems as soon as possible (GLR-32).

3.2. Continuous disinfection of all municipal waste water also should be affected as soon as possible (LER-16). Immediate measures must be instituted by the states to provide for bathing conditions which meet health standards (LER-14).

A. The immediate measures should take form of disinfection at the outlets in the vicinity of bathing areas and diversion of troublesome outlets to remote areas away from beaches since the major cause of the public health problem at bathing beaches is the discharge of fecal matter from combined storm and sanitary sewers and inadequately treated sewage (LER-14)

B. Existing public beaches should be opened for bathing as soon as adequate emergency control measures are taken (LER-14).

C. Local water pollution control agencies should establish surveillance of the sewer outlets that have been designated as affecting bathing beach areas to see that all discharges are inadequately disinfected (LER-14).

D. The beaches themselves should be continuously monitored to assure maximum protection to public health (LER-14).

COMMENTARY

Deficiencies in R & D: 3.3.2.A.

Currently sewage is disinfected through the addition of chlorine gas, which destroys most pathogenic organisms. However, there are two problems associated with this treatment. Chlorine reacts with phenols and forms chlorophenol, which causes the water to stink like hospital cleaner. (The commercial cleaner "CN" contains chlorophenol.) Most people are somewhat hesitant to bathe in such an environment.

Also, chlorination does not destroy the virus that causes hepatitis. Hence, there is a need for some other methods to rapidly and economically disinfect sewage that does not have the above problems. Some R & D has been done on using free radical oxidation[1] and ozone. However, there is a need for additional studies, which could be conducted within federal, private and academic agencies.

While diversion of troublesome outlets from beaches may appear to be a solution, it is economically and biologically unsound. Changes in currents via the wind may carry the diverted flow back to the beaches. With the cost of labor and materials, it probably would be less expensive to treat the material rather than move the pipes.

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[1] Condren, A.J. and J.E. Etzel. Waste Treatment by Free Radical Oxidation. Great Lakes Research Division Publication #15, 1966, p. 380-388.

Information for planning: 3.3.2.A

The cost for these investigations, including pilot plants, would be in the range $200,000 - $250,000 per year for three years. Such expenditures are justifiable in view of the need for additional bathing beaches, that are not subject to being closed periodically, and in the significant increase in the cases of infectious hepatitis in communities that border Lake Erie.[1]

Facilities or Equipment Problems: 3.3.2.A

Facilities and personnel to study the problem of tertiary treatment are situated at the FWPCA Cincinnati laboratories, Purdue University and several other schools with graduate programs in Sanitary Engineering.

Penalties of Postponement: 3.3.2.A

In regards to hepatitis, there has been a dramatic increase in the incidence of this illness in recent years.[2] If measures are not taken to avoid the loading of aquatic environments with this virus, which can remain virulent in water for up to ten weeks,[3] we are apt to witness larger epidemics.

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[1] Ingraham, H.S., by personnel communication 1968, (Dr. Ingraham is the Commissioner of the New York State Department of Health.)

[2] McKee, J.E. and H.W.Wolf, Water Quality Criteria, (2nd ed.) California State Water Quality Control Board Publication #3A, 1963, p. 548.

[3] Neefe, J.R. and J. Stokes, "An Epidemic of Infectious Hepatitis Apparently Due to a Waterborne Agent," Journal of the American Medical Association, Vol. 128, 1945, p. 1063.

A staff of two senior scientists, four assistants and eight technicians should be assigned to the above problem. Salaries and supplies to support such a group would amount to approximately $150,000 per year. Since this type of research requires an annual commitment until the task is completed, it is not possible to determine the total cost.

Penalties of Postponement: 3.3.2.C.-D.

Until a more rapid test is formulated, those who swim in the area of a sewage dis charge may be exposed to pathogens. Hence a higher incidence of waterborne diseases can be anticipated in the communities bordering such beaches.

3.3. All industrial wastes should receive the equivalent of secondary treatment, and those industrial wastes which cause chemical pollution should be either excluded from the lakes or receive a suitable high level of treatment (GLR-32) including:

A. Maximum reduction by the best available treatment should be implemented for the flowing wastes: acids and alkalies, oils and tarry substances, phenolic compounds and other organics which produce taste and odor problems, ammonia and other nitrogen compounds, phosphorus, suspended materials, toxic and highly colored materials, oxygen-demanding substances, excessive heat, foam-producing compounds, and other materials which detract from aesthetics or other beneficial uses of water (GLR-32)

B. Many industries in the Lake Erie Basin need treatment facilities to abate pollution and to meet established water quality standards. It is recognized that many of the industries named below already have substantial abatement programs underway or may have completed the necessary treatment facilities (LER-14):

1) The iron and steel industry should install, operate, and maintain or otherwise increase waste reduction facilities to effectively reduce taste and odor-producing substances, suspended solids, acids, oils, cyanides, and substances that cause discoloration in receiving streams, to levels that will comply with the water quality standards for Lake Erie and its tributaries. This includes but is not limited to the following industries (LER-14): Michigan: Ford Motor Co. Rouge Plant, Dearborn; Great Lakes Steel Corp., Detroit, River Rouge, and Ecorse; McLouth Steel Corp., Trenton and Gibraltar. Ohio: Interlake Steel Corp., Toledo; U. S. Steel Corp., Lorain and Cleveland; Jones & Laughlin Steel Corp., Cleveland; Republic Steel, Elyria and Cleveland. New York: Republic Steel, Buffalo; Bethlehem Steel Corp., Lackawanna; Donner Hanna Coke, Buffalo. (LER-14).

2) The petroleum industry should install, operate, and maintain or otherwise increase waste reduction facilities to reduce phenolic discharges to the extent that taste and odors are eliminated, and to reduce oil wastes to the extent that no oil films are visible in the receiving stream. This includes but is not limited to the following industries: Michigan: Mobil Oil, Detroit. Ohio: Sun Oil, Toledo; Pure Oil, Toledo; Standard Oil, Toledo and Lima; Ashland Oil, Findlay. New York: Mobil Oil, Buffalo. (LER-15).

3) The heavy chemical and rubber industry should install, operate and maintain or otherwise increase waste reduction facilities to control their discharges of suspended and disolved solids to comply with established water quality standards. This includes but is not limited to the following industries: Michigan: Allied Chemical Corp., Detroit; Pennsalt Chemical Corp., Riverview and Wyandotte; Wyandotte Chemical Corp., Wyandotte. Ohio: Firestone Tire & Rubber Co., Akron; Diamond Shamrock Corp., Painesville; Midland Ross Corp., Painesville; Reactive Metals, Inc., Ashtabula; Olin Mathieson Corp., Ashtabula; Cabot Titanium Corp., Ashtabula; B.F. Goodrich Co., Akron; Goodyear Tire & Rubber Co., Akron. New York: Allied Chemical Corp., Buffalo. (LER-15).

4) The paper, food-producing, and other allied industries should install, operate, maintain, or otherwise increase waste reduction facilities to control the discharge of suspended solids, oxygen-demanding substances, and color so that the flow from such plants meets state requirements included those for the total allocated oxygen demand load to the lake. This includes but is not limited to the following industries: Michigan: Scott Paper Co., Detroit; Darling & Co., Detroit; Time Container Corp., Monroe; Union Bag-Camp, Monroe; Michigan Milk Producers Assn., Peck and Imlay City; Port Huron Paper Co., Port Huron; Vlasic Food Products Co., Imlay City; Peninsula Paper Co., Ypsilanti; Simplex Paper Corp., Palmyra. Indiana: Parrot Packing Co., Fort Wayne. Ohio: Weston Paper Co., St. Marys; Betrice Food Co., St. Marys; Foster Duck Farm, Montgomery Twp.; Hirzel Canning Co., Pemberville; Cuyahoga Meat Co., Cleveland; Chase Bag Co., Chagrin Falls. Pennsylvania: Albro Packing Co., Springboro; Gunnison Bros., Girard Township; Hammermill Paper Co., Erie. New York: Welch Grape Juice, Westfield and Brocton; Seneca Westfield Maid, Westfield; Growers Coop Grape Juice, Westfield; Pro-Canners Corp, No. Collins; Gro-Packers Coop, No. Collins; Peter Cooper Co., Gowanda; Moench Tannery, Gowanda (LER-15).

3.4 Pesticides and herbicides should be applied to land in such a fashion so as to minimize the amounts that reach the Great Lakes as surface or subsurface ran-off (GLR-32).

A. Practices to reduce drainage of tannins or tanic acid from forests and then central or neutralization should initiated.

3.5. Thermal discharges should be managed in such a way that water quality standards are met, and these discharges are beneficially employed wherever possible (GLR-33) including:

A. Reduction of thermal pollution effects where harmful;

B. Use of heat from thermal effluents for improvement of naviagation, hydropower generation, and fisheries management.

COMMENTARY

Deficiencies in R & D: 3.5.A.

Most thermal standards for organisms were derived from laboratory experiments with organisms under controlled environments.[1] However, there are factors, both natural and introduced, that may shift the levels of thermal tolerance either up or down. For example, heavy metals will decrease the tolerance of to heat.[2]

More information should be gathered on the other environmental conditions when kills due to thermal emissions are noted. For the most part this would require a re-checking of the literature and the gathering of additional data when kills are investigated. This could most easily be handled by a federal agency, such as the FWPCA.

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[1] Kennedy, V.S. and J.A. Mihursky, Bibliography on the Effect and Temperature in the Aquatic Environment, University of Maryland Natural Resources Institute Contribution #326, 1967, p. 89.

[2] Lloyd, R., Factors that Affect the Tolerance of Fish to Heavy Metal Poisening, U.S. Public Health Service Publication #999-WP-25, 1965, pp. 181-187.

<u>Information for planning: 3.3.5.A.</u>

The cost for the above 2-3 year project survey would be approximately $50,000 per year for the salaries of four (4) library staff.

<u>Sequencing problems: 3.3.5.A.</u>

The above research should be completed before emission standards are fixed.

3.6. Treatment of oil and other hazardous materials should be undertaken so that these materials will be included from the Great Lakes (GLR-33) including:

A. Each municipality, port authority, or industry containing a harbor should establish procedures to prevent and control oil spillage in harbor waters (LER-16).

B. Interstate and federal mobilization machinery to handle potential large oil spillages in the lake proper should be strengthened (LER-16).

C. Discussions are now underway for gas and oil exploration in Lake Erie. Should such drilling proceed, the oil and gas producing industry should install and operate waste elimination equipment on rigs to be used in the U.S. waters of Lake Erie to the extent that oil and other substances do not pollute the waters of the lake (LER-16).

D. Equipment and practices should be implemented to:

1) Reduce water pollution from beneficiating or refining or or ores (taconite, copper, etc.).

2) Reduce land pollution effects of strip mining, quarrying, or dumping of tailings of ore processing in spoil banks.

3.7. Erosion control methods should be developed to minimize the amount of sediments entering the lake including:

A. Development of sedimentation basins where tributaries enter a lake (EAP).

B. Employment of erosion control methods within the basin draining into a lake as part of agricultural operations and shoreline development activity (EAP).

C. Manipulation of the shore cover to:

1) Minimize erosion potential.

2) Preserve scenic qualities.

3) Provide vegetal uptake of septic tank effluents.

3.8. Methods should be developed and applied to eliminate or reduce pollution effects of solid waste disposal or land fills at edge of lake, including:

A. Use of sanitary land fills.

B. Use of diking areas to be filled to prevent spreading of pollutants.

3.9. Alternative collection and disposal systems involving other than lake-oriented water-borne disposal systems should be developed and utilized as practical, including:

A. Export of waste out of the Great Lakes Basin to the ocean or to another drainage system.

B. Oxidation of solid particles by incineration devices.

C. Chemical decomposition, oxidation, or neutralization of waste materials.

D. Straining and precipatator devices.

E. Use of underground disposal systems, including reverse deep wells, nuclear bottles, abandoned quarries or mines.

3.10. Programs of air pollution control and weather modification should be utilized to reduce pollution to the lake from atmospheric sources (e.g., rainfall) including:

A. Development and use of pollutant-reducing fuels (fossil and non-fossil) and fuels of increased combustion efficiency.

B. Use of devices to remove harmful gaseous and particular elements from gaseous waste emissions.

C. Controlling of timing of gaseous waste emissions to coincide with favorable atmospheric dilution conditions.

3.11. Solid, liquid, and gaseous waste materials should be subject to reclamation treatment wherever practical.

4. RECOMMENDATIONS FOR R&D ON NON-NUTRIENT POLLUTION ABATEMENT MEASURES

4.1. Determination of the role of radioactive substances in Lake Erie pollution (LER-16).

4.2. Determination of the role of pesticides in Lake Erie pollution (LER-16

4.3. Determination of the effects of potential increases of thermal pollution in Lake Erie(LER-16).

4.4. R&D should be conducted in mineral extraction technologies to:

A. Reduce water pollution from beneficiating or refining or ores (taconite, copper, etc.).

B. Reduce land pollution effects of strip mining, quarrying, or dumping the tailings of ore processing in spoil banks in the lake.

5. RECOMMENDATIONS FOR R&D FOR BOTH NUTRIENT AND NON-NUTRIENT POLLUTION ABATEMENT MEASURES

5.1. R&D on the development of waste management system for Lakes Erie and Superior respectively, and for the Great Lakes Region including:

A. Design of an integrated and coordinated program of collection and disposal of solid, liquid, and gaseous wastes from municipal, industrial, and agricultural sources.

B. R&D to reduce costs and increase effectiveness of such systems.

5.2. R&D on sewerage drainage systems including:

A. R&D on technology to design, construct, and use separate storm and sanitary sewerage systems.

B. R&D to utilize combined sanitary and storm and industrial sewerage systems including R&D on various storage systems to accommodate storm surges (to accommodate storm surges to prevent overloading sewage treatment plants and dumping untreated sewage in the lake) such as reservoirs, low-cost tanks, and bladders.

C. R&D on underground disposal systems(nuclear bottles, deep wells , or abandoned quarries or mines).

D. R&D to develop effective means to reduce pollution from rural run-off(LER-16).

5.3. R&D on new products or processing technologies which reduce waste generation or pollution effects

5.4. R&D for reclamation of solid, liquid, and gaseous wastes for commercial and non-commercial uses.

5.5. R&D for the design and implementation of a comprehensive waste disposal monitoring system including:

A. Monitoring of liquid, solid, and gaseous waste emission into the lake (coastal zone) environment.

B. Establishment of monitoring systems throughout various locations and positions to ascertain inaccurate and relative information.

6. RECOMMENDATIONS FOR POLLUTION ABATEMENT STANDARDS

6.1. Michigan, Indiana, Ohio, Pennsylvania, and New York should pursue diligently and expeditiously:

A. Requirements of the enforcement conference.

B. Their plans of implementation designed to achieve the water quality standards for Lake Erie.

C. Additional recommendations specified in the Lake Erie Report (LER-12).

6.2. In order to protect the oxygen resources of inland streams in portions of the Lake Erie watershed, the following municipalities need treatment at a degree greater than secondary or connection to an area-wide collection and treatment system:

Indiana: Auburn, Decatur, Fort Wayne, Garrett.

Ohio: Akron, Amherst, Archbold, Attica, Bellevue, Berea, Bloomdale, Bloomville, Bowling Green, Brook Park, Bryan, Carey, Cleveland Southerly, Clyde, Columbus Grove, Crestline, Cuyahoga Falls, Delphos, Delta, Elyria, Findlay, Fostoria, Fremont, Gibsonburg, Grafton, Greenwich, Kent, LaGrange, Lima, McComb, Medina, Middleburg Hts., New London, New Washington, North Baltimore, North Reyalton, Norwalk, Oberlin, Olmsted Falls, Ravenna, St. Marys, Spencer, Stow, Strongsville, Tiffin, Toledo, Upper Sandusky, Van Wert, Wapakoneta, Wauseon.

New York: East Aurora, Eden Twp., Hamburg Village, Gowanda (if industrial wastes are included), Holland Twp., North Collins.

By 1990, in order to protect the oxygen resources of the basin, treatment of municipal wastes at a degree greater than secondary will be necessary throughout the basin (LER-12).

6.3. Michigan, Ohio, and Pennsylvania should adopt water quality standards for intrastate streams; and these should be consistent with those adopted for interstate waters. New York, Indiana have already adopted intrastate standards; others are presently holding or have completed hearings pursuant to the adoption of intrastate standards (LER-12).

6.4. Each of the five Lake Erie Basin states should establish and maintain waste discharge limits of oxygen-consuming substances as measured by the 5-day biochemical oxygen demand (BOD) test for each major drainage basin in the Lake Erie watershed sufficient to meet stream standards. This discharge limit should be no greater than the summation of the individual municipal and industrial waste effluent loads that will be expected when the recommendations for treatment specified in this report are met (LER-13).

6.5. Each of the states should require treatment of wastes to the extent that the basinwide total phosphorus discharged from municipal and industrial sources will not exceed 9,000 lbs/day. This will require an average reduction in the present rate of input from such sources of about 90%. By the year 1990, nearly complete removal of phosphorous from municipal and industrial wastes, together with substantial reduction in the phosphorus contributinn from run-off, will be required to accommodate projected population increase.

No cities presently treat to this level in the Lake Erie watershed although it is recognized that the states are embarking on a program to require treatment (LER-13).

7. RECOMMENDATIONS FOR R&D IN SETTING AND CONTROLLING STANDARDS FOR POLLUTION ABATEMENT

7.1. R&D to review water quality standards which have been established or are being established by appropriate authorities for the purpose of providing information useful to those authorities in refining or revising the standards, (FWS) including:

A. Examination of water quality trends in relation to present uses and potential changes in the future.

B. Development of conclusions as to the urgency of water quality problems in each hydrologic sub-area of the Great Lakes Basin (and more particularly, of the sub-basins of Lake Erie and Lake Superior) and give general cost estimates for broad components for the action needed (FWS).

7.2. R&D to identify water quality problems as to nature, location, and gravity (FWS) in the drainage basins of Lake Erie and Lake Superior.

7.3. R&D to define in general terms the actions needed to maintain or improve the quality of streams, lakes, and aquifers of the Great Lakes Basin (FWS), particularly with regard to Lakes Erie and Superior

7.4. R&D to establish meaningful control standards including:

A. Tolerance levels to various pollutants by human, animal, and plant species.

B. Delineation of reaches of streams where increased low flows and/or decreased waste loads are indicated for water quality improvement (FWS).

C. Socio-Economic values affected by the standards.

7.5. R&D on the effectiveness of legal or regulatory control measures in producing desired results with relative ease in administration or cost.

7.6. R&D to translate the economic projections and water-use data into accompanying waste loads and determine the needs for waste treatment and other measures for dealing with water-borne wastes under conditions of development projected for 1980,2000,and 2020 (FWS).

7.7. R&D to appraise the effectiveness of present practices in the treatment and disposal of water-borne wastes and determine the water quality control needs under current conditions to alternative measures for meeting these needs where appropriate (FWS).

II. RESTORATIVE MEASURES

8. RECOMMENDATIONS FOR RESTORATION MEASURES FOR THE GREAT LAKES (Lake Erie, in particular)

8.1. Removal of sediments by:

A. Dredging methods.

B. Mixing and then pumping to a separation device (GLR-43). (It would probably be most feasible to perform these tasks in segmented areas of the lake so disturbed sediments will not redeposit in previously treated areas.)

8.2. Sealing of sediments, thus preventing nutrient interchange into the overlying areas including:

A. Development of a sealing material having the characteristics of:

1) Insolubility.

2) Non-toxic.

3) Biological stability.

4) Easy to apply under water.

Potential materials that could be used are biologically stable plastics or polymeric compounds.

B. Diking so disturbed sediments will not redeposit on top of previously sealed areas (GLR-44).

8.3. Prevention of thermal stratification which results in oxygen depletion which, in turn, contributes to increased nutrient interchange at the sediment-water interface by:

A. Locating thermal power plants, both conventional and nuclear, in such a manner that their discharge outfalls induce mixing that inhibits stratification (GLR-44).

(Whether or not this can be accomplished with existing plants is speculative. However, Lake Erie could purposely be designated as a power plant center;and new power plants in the Midwest could be located on Lake Erie to aid in such a destratification effort.)

B. Regulating flows and currents in selected areas to stimulate vertical mixing of waters.

C. Placement of heat generators at selected bottom locations to cause vertical convestion currents.

8.4. Flushing with low-nutrient water (GLR-42)

A. Because of the very large size of the Great Lakes, flushing with low-nutrient water is not feasible using water within the Great Lakes Basin alone. However, several continental water plans under study could add significant amounts of this type of water to the Basin (GLR-42).

B. It would be highly appropriate to determine what the effects of these continental water plans would be for the Great Lakes Basin, and efforts should be made to incorporate concepts designed to restore water quality early in the planning stages (GLR-42).

8.5. Collection and removal of algae and harvesting of aquatic weeds which cover large areas of Lake Erie and concentrate along the shoreline during certain periods of the year (GLR-42).

A. Some difficulty has been encountered in the past because of equipment constraints, mainly algae fouling during the separation step, and the fact that present equipment functions only over small areas. If this technique is to be used on large scale, these problems must be overcome (GLR-42).

B. Algae and aquatic weeds should be disposed in a fashion so that nutrients will not re-enter the lakes (GLR-42).

8.6. Development and use of an Algacide

The development of an algacide for selectively controlling blue-green algae would be beneficial to the restoration of Lake Erie. Because of presently limited knowledge, considerable effort might be required to discover an algacide capable of blue-green algae control without having marked effects on the total ecological balance of the lake (GLR-42).

8.7. Development of predators, parasites, or viruses specific for aquatic plants

A. Predators, parasites, or viruses which are specific for blue-green algae and rooted vegetation can be used for restoration. This method also is not well defined and could entail considerable developmental work. The ecological balance could also be affected by this measure, and there should be adequate assurance that secondary effects are not adverse (GLR-43).

B. Development of species of zooplankton ton consume algae, and a species of trash fish to use the large supply of zooplankton as food and, thereby, support commercial fishing activity for fish meal production. Equipment is also being developed to harvest Antarctic krill -- a species of larger zooplankton -- and which could also be utilized in Lake Erie if asimilar zooplankton species could be developed and established.

8.8. Use of substances which interfere with light penetration

Algae growth can be impeded by the addition of a substance which interferes with light penetration. This substance must be non-toxic, biologically stable, and non-restrictive to oxygen transfer. The substance has yet to be discovered and likely would entail considerable research. Problems with ecological imbalances could be severe in this case also (GLR-43).

8.9. Use of divalent cation chelating agents to inhibit blue-green algae proliferation

Since divalent cations serve as co-enzymes in algae growth, divalent cation chelating agents could be used to inhibit blue-green algae proliferation. Ecological consequences must be considered. Biologically stable chelators are now available, and some may be suitable for this proposed use. Assuming that the chelator selected is readily soluble, it could be broadcast aerially to affected areas in the lakes. Full knowledge of critical inhibitory concentrations of chelating agents, mixing parameters, and dispersal effects must be available prior to implementation (GLR-43).

9. RECOMMENDATIONS FOR R&D IN THE RESTORATION OF LAKE ERIE

9.1. R&D to determine the exact role of Lake Erie bottom sediments in the overall chemistry of the lake (LER-16).

9.2. R&D for developing effective means to prevent the formation of oxygen-deficient zones in mid-Lake Erie (LER-16).

9.3. R&D to develop effective means to restore the Lake Erie fishery (LER-16).

9.4. A detailed conomic analysis should be undertaken to identify the quantifiable benefits that would accrue for various levels of improvement in the quality of the Great Lakes resources and the associated costs of achieving these levels including: (GLR-6)

A. Consideration of foreign benefits if resources management practices are not improved (GLR-6).

B. Consideration of all significant aspects including domestic, municipal, and industrial water supply, power, irrigation, agriculture, watershed mangement, recreation, aquatic resources including commercial and sport fisheries, and navigation including pleasure boating (GLR-6).

(Without the knowledge that such an analysis would provide, the most desirable and justifiable level of water quality remains a matter of conjecture and debate; and any restoration program would lack direction and a defensible goal (GLR-6).

APPENDIX B

GENERAL CATEGORIES OF WATER POLLUTION SUBSTANCES[1]

Water polluting substances may be classified into eight general categories, each of which is somewhat unique in pollutional characteristics and effects:

1. Oxygen Demanding Wastes--the traditional organic wastes contributed by domestic sewage and industrial waste of plant and animal origin (food processing, papermill, vegetable tanning, etc.). During decomposition in water, these wastes consume the dissolved oxygen required by fish. When all oxygen is thus consumed, septic conditions result.

2. Infectious Agents--disease-causing organisms which are carried into surface and ground water by sewage from municipalities, institutions and sanitariums, and by certain industrial wastes such as tanning and slaughter-houses. These wastes may transmit the microbes causing enteric (e.g., typhoid fever) and viral diseases.

3. Plant Nutrients--principally nitrogen and phosphorus contributed by sewage, certain industrial wastes and drainage from fertilized lands. These stimulate growths of water plants, such as algae, causing disagreeable

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[1] Based on definitions presented in "Causes and Extent of the National Water Pollution Problem," Division of Water Supply and Pollution Control, Public Health Service, U.S. Department of Health, Education and Welfare, from *Water Pollution Control and Abatement*, Part 1A--National Survey, included in Hearings Before a Subcommittee of the Committee on Government Operations, House of Representatives, 88th Congress, First Session, May 21 - June 5, 1963.

conditions and, upon their death and decay, causing secondary oxygen consumption. Such plant nutrients are not removed by biological waste treatment which on the contrary, makes them more usuable by plant life.

4. Synthetic Organic Exotics--a new category including household detergents, synthetic organic pesticides, a variety of synthetic industrial chemicals and the wastes from their manufacture. These rapidly augmenting pollutants, which are extremely resistant to conventional waste treatment, cause undesirable effects on water for human use and are believed toxic to aquatic life--and possibly humans. Much more needs to be known about the toxicity of these products and methods of treatment and/ or control.

5. Inorganic Chemical and Mineral Substances--includes a great variety of mineral and inorganic wastes (metals, metal salts, acids, and solid particles) resulting from mining, manufacturing processes, oil field operations, agricultural practices, and natural sources. These materials may interfere with natural stream purification; destroy aquatic life; cause excessive hardness, corrode expensive water treatment and industrial equipment, and concrete or steel structures; and increase the costs of treating water and maintaining watercraft. Some of the metals and their compounds--e.g., lead and cyanides--are known to be toxic.

6. Sediments--inorganic particles of soils, sands, and mineral matters washed from the land and from hard surfaced areas (streets, buildings, airports, etc.). While not so insidious in pollutional characteristics as other agents, sediments cause major problems from their sheer magnitude, filling stream channels, harbors and reservoirs, eroding power turbines; reducing fish and shellfish populations by blanketing action; reducing sunlight penetration required by oxygen producing plants, and increasing costs of water use and treatment.
7. Radioactive Substances--results from the mining and processing of radioactive ores; from the use of refined radioactive materials in power reactors, and for industrial, medical, and research purposes, and from fallout following weapons testing. Now at a low level due to careful controls at the sources and the nuclear test ban, the increased use of radioactive substances for a variety of nonmilitary purposes poses a serious potential public health problem, physiologically. The problem can be contained by careful controls affecting the total human environment of which water is an important element.
8. Heat--great volumes of heat are added to water used for cooling purposes by steam-electric powerplants, steel mills, petroleum refineries, petro-chemical plants, and other industries. Heat returned to lakes, streams and coastal waters has the effect of a pollutant because it reduces the solubility of oxygen in water and thus its ability to

assimilate oxygen-consuming pollutants and to support fish and aquatic life. It also has direct detrimental effect on fish sensitive to temperature and can virtually eliminate normal aquatic life. A second source of heat in water is reservoir storage during summer months, causing stratification of waters with the cooler lower layers becoming oxygen deficient before passing through lower gates of a dam with ill effects on water quality downstream.

APPENDIX C

RECOMMENDATIONS OF THE TASK FORCE ON ENVIRONMENTAL HEALTH AND RELATED PROBLEMS

excerpted from: A Strategy for a Livable Environment, U. S. Department of Health, Education, and Welfare, Washington, D. C., June 1967, pp. xviii - xix.

STRATEGY

To protect man from the adverse effects of environmental change, the Department of Health, Education and Welfare needs to know the problems, measure them devise means to solve them and obtain compliance with regulatory standards. If this approach is to be successful, there must be an adequate supply of competent manpower, and a public awareness of the dangers. All of this can be accomplished through an Environmental Protection System. The Task Force believes that the Department will be able to cope with environmental health problems of the future by implementing the following recommendations.

We recommend that the Department:

1. Establish a surveillance and warning program which will, through basic research, identify current and potential problems, and determine the effect of these problems on man, thus giving the Department the continuing supply of scientific knowledge necessary to protect man from environmental injury and aesthetic insult.

2. Establish an environmental design program which will establish criteria and dual-level standards for individual hazards and combinations of hazards under varying conditions of geography, population, industrialization, economics, and technology, with one level being the minimum health level acceptable and the other being a desirable level which can be achieved in a specific number of years.

3. Establish a technological development program using contracts with industry in conjunction with Departmental activities and grants to institutions so as to bring about the technological improvement necessary to reach the desirable environmental quality levels.

4. Establish an inter-governmental compliance program using Federal functionally orientated grants-in-aid free of formula and allocation restrictions in conjunction with Federal technical assistance teams to obtain comprehensive plans and action from State and local governments consistent with national goals and objectives.

If this Environmental Protection System is to succeed, specific immediate objectives need to be reached.

The Task Force recommends:

1. Development by 1970 of a nationwide surveillance system necessary for identifying

levels of pollutants and components of pollutants in air, water, and soil. (Chapter III, page 34)

2. Establishment by 1970 of criteria for individual and combinations of chemicals discharged into air, water, or soil.

3. Require by 1969 the filing of five-year comprehensive environmental health plans from State and local governments receiving funds from the Department.

4. Creation by 1968 of a permanent technical assistance unit within the Department which can provide multi-disciplined teams of specialists to be available to State and local governments at their request to aid in planning and implementing environmental health programs.

5. Determination by 1969 of the manpower requirements necessary to adequately supply both public and private sector needs for environmental program operations beginning in 1972 and beyond, and the means of supplying such needs.

6. Establishment by 1968 of an integrated effort for health education and general education to create a public understanding of its environment and an increased awareness of the individual and social responsibility, in reference to it.

OTHER RECOMMENDATIONS:

The foregoing recommendations deal with goals and strategy. In addition, however, are the following recommendations which relate to the goals and the protection system. Those having the highest priority are listed here.

The Task Force recommends the Department:

1. Urge the President to call a White House Conference on Financing Local Government to explore ways for cities and other units of local government to raise adequate funds to finance essential governmental activities on a metropolitan and regional scale.

2. Urge the President to seek Congressional authorization to create a Council of Ecological Advisors to provide an overview to assessment of activities in both the public and private sectors affecting environmental change, and to act in an analyzing capacity, to be in a commanding position to advise on critical environmental risk/benefit decisions, and finally to be instrumental in the shaping of national policy on environmental managment.

3. Seek authority to provide air pollution program grants only to those control agencies which develop emergency plans that would control combustion activities under certain air pollution alert conditions.

4. Accelerate within the Department of Health, Education, and Welfare a national family planning program to disseminate family planning information to all requesting State and local health agencies, physicians, private associations, and individuals.

5. Develop urban and rural model codes and suggested standards for the prevention and control of various sources of noise in the environment. (Chapter II, page 19)

6. Contract with appropriate universities and/or research institutions for the establishment and operation of a facility for large scale, long term, health related studies in human acology.

7. Undertake a grants program for the establishment and support of university-based centers for ecologically-orientated environmental health studies.

8. Create through contracts a non-profit research organization using experts in a wide variety of fields to respond exclusively to the Department's need for problem-solving in the health and environmental health areas.

9. Establish an Office of Assistant Secretary for Research and Development so that activities within, or supported,by, the Department are integrated into a total systems approach and provided with overview, direction, and control.

10. Provide grant-in-aid or contract support for the establishment and operation of urban sociological health research centers in major metropolitan areas.

11. Establish units of the Department of Health, Education, and Welfare in other Federal agencies to provide liaison to those agencies and an assessment of the effects of their programs on man's environmental health and welfare.

12. Provide fellowships for in-service training and continued education for Departmental personnel in the environmental health field.

13. Promote the establishment of programs and curricula in clinical and human ecology through grants to the Nation's professional schools, such as schools of medicine, law, public health, and public administration.

14. Provide fellowships for State and local personnel to permit them to continue their education in environmental health fields.

APPENDIX D

Summary of Pollution Control Legislation for State Contigious to Lake Erie and Lake Superior[1]

MICHIGAN

Water

Legislation:Act 245, Public Acts of 1929, as amended Act creates 7-member Water Resources Commission. Defines unlawful pollution and authorizes Commission to establish water quality standards and control pollution. Local governments made responsible for resident sewage. Specifies cooperative duties for control of floods, beach erosion and stream gaging.

Agency powers: 1. Issue orders. 2. Restrict new disposals. 3. Enforce laws.

Standards submitted to WPCA, approved April 17, 1968, except for temperature increases allowed.

Penalties: $500 each day of violation.

Tax relief: Exemption from personal property and sales taxes for industrial pollution control facilities.

Assistance:For alternate methods of solving pollution problems.

Further information: Water Resources Commission, Dept. of Conservation, Station B, 200 Mill Street, Lansing, Mich. 48913.

Air

Legislation: Air Pollution Act, Act 348, 1965. Act establishes a 9-member Air Pollution Control Commission, 6 citizens and 3 State Dept. employees. Purpose: adopt rules and regulations; set up violation and variance proceedings; provide penalties.

Agency powers; 1. Set standards and limits. 2. Compel compliance. 3. Develop plans.

Penalties: Up to $500 plus $100/day for each additional day.

Tax Relief: Tax exemptions from state and local taxes for air pollution control equipment.

Further Information: Div. of Occupational Health, Michigan Dept. of Health, Lansing, Mich.

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1 "State Regulations," Chemical Engineering, October 14, 1968, pp.25-48.

MINNESOTA

Water

Legislation: Minnesota Laws 1945, Ch. 395; Extra Session Laws, 1961, Ch. 20; Laws, 1963, Chap. 874; Laws, 1967, Chap. 882. Laws give Pollution Control Agency, formerly Water Pollution Control Commission, authority over water pollution and the problems of solid waste disposal. Water quality standards to be set both for effluent content and purity of receiving stream.

Agency powers: 1. Set quality standards. 2. Inspect plans. 3. Issue permits. 4. Enforce compliance. 5. Issue orders. 6. Assume municipality powers to construct disposal system and levy taxes.

Standards submitted to WPCA, approved conditionally, June 18, 1968.

Penalties: Injunction. $100 or 90 days in jail.

Tax Relief: Device installed solely for anti-pollution purposes will not be taxed either as personal property or realty improvement.

Assistance: Consultations and interpretations, all with technical people.

Further information: Minnesota Pollution Control Agency, 459 Board of Health Bldg., University Campus,Minneapolis, Minn. 55440.

Air

Legislation: Chapter No. 882, S. F. No. 845, Minnesota Statutes 1967, May 1967. Law establishes a Pollution Control Agency responsible for Air and Water Pollution Control, Solid Waste Disposal, and Land Use Planning where such use increases pollution control problems. Agency may adopt, amend or rescind regulations and standards for prevention, abatement or control of pollution. Standards may relate to emissions or ambient air. Division of Air Quality formed to establish standards.

Agency powers:May enforce standards and regulations by injunction, action to compel performance or other action in district court of any county where provision is effective.

Penalties: Imprisonment of 90 days or $100 fine. Each day a separate offense.

Tax Relief: Installations solely for control of air pollution are exempt from real or personal property taxes.

Assistance: Available soon. Chief of division is a registered P.E. and more engineers are being hired.
Further information: Minnesota Pollution Control Agency, 459 State Board of Health Bldg., University Campus, Minneapolis, Minn. 55440.

NEW YORK

Water

Legislation: New York State Public Health Law, Article 12, 1954. Law declares public policy of State to maintain reasonable water purity standards consistent with public health and enjoyment, protection of fish and wildlife and industrial development, and to require use of all known and reasonable methods to prevent and control pollution in State waters.

Agency powers: 1. Hold hearings. 2. Issue orders. 3. Issue extend, deny,revoke or modify permits. 4. Conduct investigations.

Standards submitted to WPCA, not approved yet.

Penalties: Injunction. Fine of $100-500 per day of violation.

Tax relief: Tax exemptions after approval and inspection by Health Dept.

Also a member of Interstate Sanitation Commission, Ohio River Valley Water Sanitation Commission, New England Interstate Water Pollution Control Commission, Interstate Commission on Lake Champlain Basin, Delaware River Basin Commission.

Further information: New York State Dept. of Health, Office of Counsel, 84 Holland Avenue, Albany, N. Y. 12208.

Air

Legislation: Article 12-A, Public Health Law, April 1957. Law establishes 9-member Air Pollution Control Board. Purpose: To adopt and promulgate regulations. Also provides for Commissioner of Health and staff. Purpose: To enforce regulations and carry out control program.

Agency powers: 1. The Board can determine degree of pollution and emission standards. 2. Prepare a plan for pollution control and abatement. The Commissioner san 1. Conduct studies and research. 2. Conduct demonstrations. 3. Provide training facilities and staff. 4. Receive monies. 5. Consider and approve plans and specifications. 6. Inspect premises.

Penalties: Fine of $1,000 plus $200 each additional day.

Tax relief: Yes, for certified pollution control equipment only.

Assistance: To local air pollution programs, but not to pollutors.

Further information: Division of Air Resources, New York State Dept. of Health, 84 Holland Avenue, Albany, N. Y. 12208.

OHIO

Water

Legislation: Water Pollutinn Control Act, Sec. 6111.01 through 6111.40, 6111.99, Ohio Revised Code, 1951. Amended 1953, 1965, 1967. 1951 Act created a Water Pollution Control Board with administrative, regulatory and quasi-judicial powers. 1967 amendment gives six members.

Agency powers: 1. Conduct research, education and investigation. 2. Enforce programs. 3. Require construction or modification of sewage or waste disposal systems. 4. Suspend construction. 5. Obtain injunctions.

Standards submitted to WPCA, approved with exceptions, March 4, 1968.

Penalties: $500 and/or one year imprisonment.

Tax Relief: Certificates of exemption from personal, property, franchise, sales and use taxes for approved water pollution control facilities.

Assistance: Conferences, operator schools.

Also a member of Ohio River Valley Water Sanitation Commission, Great Lakes Commission.

Further information: Ohio Water Pollution Control Board, P. O. Box 118, Columbus, Ohio 43216.

Air

Legislation: Sections 3704.01 to 3704.11 inclusive and Section 3704.99 of Ohio Revised Code, Enacted as Amended Substitute House Bill 689, Aug. 10, 1967. Effective date Nov. 24, 1967. H. B. 689 establishes within the Ohio Dept. of Health a 5-member board, the Ohio Air Pollution Control Board. Purpose: to develop programs for prevention, control and abatement of pollution; to develop a plan to control air pollution from state-operated facilities; to advise, consult and cooperate with other agencies; to accept and administer grants; to obtain necessary technical services; and to employ, compensate and prescribe duties and powers of personnel.

Agency powers: 1. Prescribe ambient air quality and emission standards. 2. Conduct studies, investigations and research. 3. Conduct monitoring. 4. Require persons responsible for pollution sources to file reports on emissions. 5. Require submission of plans. 6. Issue conditional permits for emissions in excess of standards complete with control recommendations and time table for compliance.

Penalties: Injunctive relief and/or $500 per offense upon conviction. Each day is a separate offense.

Tax Relief: Exemption from franchise, real property, use and sales taxes offered to qualified facilities.

Assistance: Available for development of control programs, writing of regulations, training of personnel, analytical service, field studies and single source investigations.

Also a member of Ohio-West Virginia Insterstate Compact, which is awaiting U. S. Congressional action.

Further information: Ohio Dept. of Health, P. O. Box 118, Columbus, Ohio 43216.

PENNSYLVANIA

Water

Legislation: Clean Streams Law, 1937, P. L.1987(as amended),35 P.S. Par. 691.1 et seq. Law forbids discharge of industrial or sewage wastes into State waters. Objective is not only to prevent further pollution, but to restore to a clean state every stream in Pennsylvania that is now polluted.[1]

Agency powers: 1. Require discharge permits. 2. Set treatment standards. (Sanitary Water Board).

Standards submitted to WPCA, approved May 21, 1968.

Penalties: $100-5,000 plus imprisonment up to one year.

Also a member of ORSANCO, Interstate Commission on the Potomac River, Delaware River Basin Commission, Great Lakes Commission, International Joint Commission.

Further information: Sanitary Water Board, Pennsylvania Dept of Health, P. O. Box 90, Harrisburg, Pa. 17120.

Air

Legislation: Air Pollution Control Act, January 1960, as amended, Act establishes Air Pollution Commission and Air Pollution Control Associations in regions designated by Commission. Commission is regulatory agency, Health Dept. receives and investigates complaints, conducts surveys and testing programs, issues and enforces orders.

Agency powers: 1. Commission adopts rules and regulations. 2. Health Dept. enforces these orders.

Penalties: Fine up to $500 or imprisonment from 10-30 days.

Assistance: Staff available on request for consultation and/or assistance in design or development.

Further information: Div. of Air Pollution Control, Penna. Dept. of Health, P.O. Box 90, Harrisburg, Penna. 17120.

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1. A bond issue will be voted on for $335 million for water pollution control support and $100 million for recreation.

WISCONSIN

Water

Legislation: Water Resources Act, Chap. 614. Laws of 1965; Air Pollution and Solid Wastes Disposal Control, Chap. 83, Laws of 1967. Act centralizes program authority; establishes shoreland and flood plain zoning requirements; makes certification of waterworks and sewage treatment plant operators mandatory; sets up a state financial assistance program for municipal construction; strengthens enforcement; authorizes water quality standards. The solid wastes disposal act authorizes establishment of state standards with control of disposal and incineration through licensing.

Agency powers: 1. Monitor surface water quality. 2. Conduct stream surveys. 3. Hold hearings. 4. Issue orders. 5. Approve plans. 6. Disburse State and Federal aid. 7. Issue licenses and permits.

Standards submitted to WPCA, approved January 1968.

Penalties: Up to $5,000 each day of violation.

Tax relief: One-year amortization on pollution abatement facilities. Permanent exemption from real estate taxes for equipment.

Assistance: Five regional offices staffed by engineers, sanitarians and biologists provide on-the-scene advisory services. Review of all plans by Division prior to construction.

Also a member of Great Lakes Basin Commission. Resolutions adopted in conjunction with all neighboring states.

Further information: Div. of Resources Development. Dept. of Natural Resources, State Office Bldg. 1 W Wilson St. Madison, Wis. 53702

Air

Legislation: Chap. 83. Laws of 1967, enacted August 1967. Law authorizes State to adopt state-wide air pollution standards and enforce laws, establish standards governing solid waste disposal sites; creates air pollution advisory council.

Agency powers: 1. Issue orders and emergency orders related to abatement of air pollution. 2. Render technical assistance, advice and counsel. 3. Encourage county wide air pollution control.

Penalties: $5,000/day, each day.

Tax relief: Air pollution control facilities are exempt from local taxation, subject to agency approval.

Assistance: At regional office level by regular contact. Central office reviews plans and determines compliance.

Further information: Div. of Environmental Protection, Dept. of Natural Resources, State of Wisconsin, Madison, Wisc.

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1. A $200 million bond plan is to be voted upon in April of 1969, of which about $144 million is scheduled for municipal sewage construction, and the remainder to be used for recreation development.

APPENDIX E

CURRENT REFERENCE CALLING FOR AN INTERNATIONAL JOINT COMMISSION REPORT ON POLLUTION IN LAKE ERIE, LAKE ONTARIO AND THE INTERNATIONAL SECTION OF THE ST. LAWRENCE RIVER

"I have the honor to inform you that the Governments of the United States and Canada have been informed that the waters of Lake Erie, Lake Ontario and the international section of the St. Lawrence River are being polluted by sewage and industrial waste discharged into these waters. Having in mind the provision of Article IV of the Boundary Waters Treaty signed January 11, 1909, that boundary waters and waters flowing across the boundary shall not be polluted on either side to the injury of health or property on the other side, the two Governments have agreed upon a joint Reference of the matter to the International Joint Commission, pursuant to the provisions of Article IX of said Treaty. The commission is requested to inquire into and to report to the two Governments upon the following questions:

(1) Are the waters of Lake Erie, Lake Ontario and the international section of the St. Lawrence River being polluted on either side of the boundary to an extent which is causing or is likely to cause injury to health or property on the other side of the boundary?

(2) If the foregoing question is answered in the affirmative, to what extent, by what causes, and in what localities is such pollution taking place?

(3) If the Commission should find that pollution of the character just referred to is taking place, what remedial measures would, in its judgment, be most practicable from the economic, sanitary and other points of view and what would be the probable cost thereof?

"In the conduct of its investigation and otherwise in the performance of its duties under this Reference, the Commission may utilize the services of engineers and other specially qualified personnel of the technical agencies of the United States and Canada and will so far as possible make use of information and technical data heretofore acquired or which may become available during the course of the investigation.

"The two Governments are also agreed on the desirability of extending this Reference to other boundary waters of the Great Lakes Basin at an appropriate time. The Commission is requested to advise the Governments when, in its opinion, such action is desirable.

"The Commission should submit its report and recommendations to the two Governments as soon as practicable."

APPENDIX F

GENERAL U.S. SHORELINE USE OF LAKE ERIE AND LAKE SUPERIOR, 1966
Including Niagara, Detroit, and St. Clair Rivers and Lake St. Clair[1]
(in miles)

LAKE ERIE	Total Length of Shoreline	Industrial	Commercial	Residential (Seas.)	Residential (Perm.)	Agric. and Silvicult.	Fish & Wldlfe	Recr. (Fed./State)	Recr. (Local/Priv.)	Undev.	Miles of Existing Protective Structures
NEW YORK											
Niagara County											
Niagara River											
Mainland	25.25	0.90	5.00	0.60	5.50	---	---	8.40	1.00	3.85	6.34
Cayuga Island	3.00	---	---	---	2.40	---	---	---	0.60	---	0.40
Tonawanda Island	1.70	1.10	0.60	---	---	---	---	---	---	---	0.86
Total Niagara County	29.95	2.00	5.60	0.60	7.90	---	---	8.40	1.60	3.85	7.60
Total Percentage for Niagara County	(100%)	6.7	18.7	2.0	26.4	---	---	28.0	5.3	12.9	25.4
Erie County											
Niagara River											
Mainland	6.00	2.80	0.50	---	---	---	---	---	1.70	1.00	---
Grand Island	23.60	---	12.50	0.70	2.30	---	---	5.55	---	2.55	0.74
Lake Erie	29.82	3.86	5.37	3.18	5.40	0.10	---	0.90	1.70	9.31	8.25
Total Erie County	59.42	6.66	18.37	3.88	7.70	0.10	---	6.45	3.40	12.86	8.99
Total Percentage for Erie County	(100%)	11.2	31.0	6.5	13.0	0.1	---	10.9	5.7	21.6	15.1
Chautaqua County - Lake Erie	41.08	0.60	3.15	4.09	3.26	6.20	---	1.42	2.11	20.25	4.67
Total Percentage for Chautaqua Cty.	(100%)	1.5	7.8	10.0	8.0	15.1	---	3.5	5.1	49.0	11.4
TOTAL NEW YORK	130.45	9.26	27.12	8.57	18.86	6.30	---	16.27	7.11	36.96	21.26
TOTAL PERCENTAGE FOR NEW YORK	(100%)	7.1	20.8	6.6	14.5	4.8	---	12.5	5.5	28.2	16.3
PENNSYLVANIA											
Erie County - Lake Erie	48.35	1.75	0.93	4.41	5.01	4.03	---	7.95	4.73	19.54	6.17
Total Percentage for Erie County AND TOTAL FOR PENNSYLVANIA	(100%)	3.6	1.9	9.1	10.5	8.3	---	16.4	9.8	40.4	12.8
OHIO											
Ashtabula County - Lake Erie	26.75	1.80	1.98	4.19	4.03	---	---	0.80	2.41	11.54	6.19
Total Percentage for Erie County	(100%)	6.7	7.4	15.7	15.1	---	---	3.0	9.0	43.1	23.1
Lake County - Lake Erie	30.30	3.45	0.24	2.80	8.78	1.00	---	0.76	3.62	9.65	6.62
Total Percentage for Lake County	(100%)	11.4	0.8	9.2	29.0	3.3	---	2.5	11.9	31.9	21.8
Cuyahoga County - Lake Erie	29.27	1.00	8.57	---	14.26	---	---	---	4.57	0.87	14.78
Total Percentage for Cuyahoga Cty.	(100%)	3.4	29.3	---	48.7	---	---	---	15.6	3.0	50.5

LAKE ERIE (Continued)	Total Length of Shoreline	Indst.	Comm.	Resid. (Seas.)	Resid. (Perm.)	Ag. & Silvct.	Fish & Wldlfe	Recr. (Fed./ State)	Recr. (Local/ Priv.)	Undev.	Miles of Existing Protective Structures
Lorain County - Lake Erie	21.38	0.85	4.82	0.48	10.95	---	---	---	0.88	3.40	8.25
Total Percentage for Lorain Cty.	(100%)	4.0	22.5	2.3	51.2	---	---	---	4.1	15.9	38.6
Erie County - Lake Erie											
Mainland	21.92	0.20	2.22	2.94	6.66	---	---	---	1.41	8.49	3.99
Sandusky Bay	11.54	0.48	4.05	0.36	1.25	1.80	---	---	0.17	3.43	7.66
Total Erie County	33.46	0.68	6.27	3.30	7.91	1.80	---	---	1.58	11.92	11.65
Total Percentage for Erie County	(100%)	2.0	18.7	9.9	23.7	5.4	---	---	4.7	35.6	34.8
Sandusky County - Sandusky Bay	4.02	---	---	0.52	0.23	---	---	---	---	3.27	0.37
Total Percentage for Sandusky Cty.	(100%)	---	---	12.9	5.8	---	---	---	---	81.3	9.2
Ottawa County - Lake Erie											
Mainland	85.93	1.4	8.75	9.54	20.21	4.2	7.8	5.4	2.01	26.62	8.14
Sandusky Bay	16.04	---	4.17	2.17	1.23	---	---	---	1.65	6.82	4.53
Total Ottawa County	101.97	1.4	12.92	11.71	21.44	4.2	7.8	5.4	3.66	33.44	12.67
Total Percentage for Ottawa Cty.	(100%)	1.4	12.7	11.5	21.0	4.1	7.6	5.3	3.6	32.8	12.4
Lucas County											
Lake Erie - Mainland	20.2	2.2	---	2.9	2.5	1.5	9.8	---	---	1.3	4.7
Maumee River	5.7	2.0	0.2	---	2.1	---	---	---	0.6	0.8	2.8
Ottawa River	2.0	---	0.1	---	1.9	---	---	---	---	---	0.1
Total Lucas County	27.9	4.2	0.3	2.9	6.5	1.5	9.8	---	0.6	2.1	7.5
Total Percentage for Lucas County	(100%)	15.1	1.1	10.4	23.3	5.4	35.1	---	2.2	7.4	26.9
TOTAL OHIO	275.05	13.38	35.10	25.90	74.10	8.50	17.60	6.96	17.32	76.19	68.03
TOTAL PERCENTAGE FOR OHIO	(100%)	4.9	12.8	9.4	26.9	3.1	6.4	2.5	6.3	27.7	24.7
MICHIGAN											
Monroe County											
Lake Erie - Mainland	39.1	0.7	0.3	5.7	7.2	0.3	16.8	1.4	1.8	4.9	---
Huron River	3.0	---	0.1	---	0.2	---	---	---	---	2.7	---
Total Monroe County	42.1	0.7	0.4	5.7	7.4	0.3	16.8	1.4	1.8	7.6	---
Total Percentage for Monroe Cty.	(100%)	1.7	1.0	13.5	17.6	0.7	39.8	3.3	4.3	18.1	---

LAKE ERIE (Continued)	Total Length of Shoreline	Indst.	Comm.	Resid. (Seas.)	Resid. (Perm.)	Ag. & Silvct.	Fish & Wldlfe	Recr. (Fed./State/	Recr. (Local/ Priv.)	Undev.	Miles of Existing Protective Structures
Wayne County											
Detroit River											
Mainland	31.0	16.2	2.7	---	5.0	---	3.8	---	3.3	---	17.25
Grosse Island	21.0	---	---	---	15.0	---	0.8	---	---	5.2	1.3
River Rouge Shortcut	2.2	2.2	---	---	---	---	---	---	---	---	0.6
Belle Isle	6.0	---	---	---	---	---	---	---	6.0	---	3.6
St. Clair River - Mainland	7.3	---	---	---	3.4	---	---	3.5	0.4	---	3.9
Total Wayne County	67.5	18.4	2.7	---	23.4	---	4.6	3.5	9.7	5.2	26.65
Total Percentage for Wayne County	(100%)	27.3	4.0	---	34.6	---	6.8	5.2	14.4	7.7	39.5
Macomb County											
Lake Erie - Mainland	29.1	0.1	1.7	0.3	19.1	---	1.5	---	5.1	1.3	10.86
Clinton River	9.2	---	1.3	---	7.9	---	---	---	---	---	5.0
Total Macomb County	38.3	0.1	3.0	0.3	27.0	---	1.5	---	5.1	1.3	15.86
Total Percentage for Macomb County	(100%)	0.3	7.8	0.7	70.6	---	3.8	---	13.4	3.4	41.5
St. Clair County											
Lake St. Clair - Mainland	10.9	---	0.1	---	10.4	---	---	---	---	0.4	4.1
St. Clair River											
Mainland	36.5	3.1	3.0	2.2	22.6	---	1.0	3.1	1.0	0.5	10.58
Hangen's Island	18.0	---	---	5.0	8.0	---	5.0	---	---	---	3.2
Black River	1.5	0.2	1.3	---	---	---	---	---	---	---	0.4
(Lake Huron Not Included)											
Total St. Clair County	66.9	3.3	4.4	7.2	41.0	---	6.0	3.1	1.0	0.9	18.28
Total Percentage for St. Clair Cty.	(100%)	4.9	6.6	10.8	61.3	---	9.0	4.6	1.5	1.3	27.3
TOTAL MICHIGAN	214.70	22.50	10.50	13.20	98.80	0.3	28.90	8.00	17.60	15.00	60.79
TOTAL PERCENTAGE FOR MICHIGAN	(100%)	10.5	4.9	6.1	46.0	0.1	13.5	3.7	8.2	7.0	28.3

LAKE ERIE (Continued)	Total Length of Shoreline	Indst.	Comm.	Resid. (Seas.)	Resid. (Perm.)	Ag. & Silvct.	Fish & Wldlfe	Recr. (Fed./ State/	Recr. (Local/ Priv.)	Undev.	Miles of Existing Protective Structures
Subtotal											
Niagara River Shoreline	59.55	4.80	18.60	1.30	10.20	---	---	13.95	3.30	7.40	8.34
Subtotal Percentage for NRS	(100%)	8.1	31.2	2.2	17.2	---	---	23.4	5.5	12.4	14.0
Detroit River Shoreline	60.2	18.4	2.7	---	20.0	---	4.6	---	9.3	5.2	22.75
Subtotal Percentage for DRS	(100%)	30.6	4.5	---	33.2	---	7.7	---	15.4	8.6	37.8
Lake St. Clair Shoreline	10.9	---	0.1	---	10.4	---	---	---	---	0.4	4.10
Subtotal Percentage for LSCS	(100%)	---	0.9	---	95.4	---	---	---	---	3.7	37.6
St. Clair River Shoreline	63.3	3.3	4.3	7.2	34.0	---	6.0	6.6	1.4	0.5	18.08
Subtotal Percentage for SCRS	(100%)	5.2	6.8	11.4	53.7	---	9.5	10.4	2.2	0.8	28.6
Lake Erie Shoreline	474.70	20.39	47.95	43.58	122.17	19.13	35.90	18.63	32.76	134.19	102.98
Subtotal Percentage for LES	(100%)	4.3	10.1	9.2	25.7	4.0	7.6	3.9	6.9	28.3	21.7
GRAND TOTAL: LAKE ERIE BASIN SHORELINE	688.65	46.89	73.65	52.08	196.77	19.13	46.50	39.18	46.76	147.69	156.25
(STUDY AREA)	(100%)	7.0	11.0	7.8	29.4	2.9	7.0	5.8	7.0	22.1	23.4

1 Source: The figures were compiled from data collected by the U.S. Army Corps of Engineers for the Shore Property Investigatic of the Great Lakes Regulation Study being conducted in cooperation with the International Great Lakes Levels Board of the International Joint Commission.

2 LEGEND:

Industrial: Exisiting length of shoreline occupied for industrial use and estimated probable future expansion (for local planning agency)
Commercial: Existing length of shoreline occupied for commercial use and estimated probable future expansion (for local planning agency)
Residential (Seasonal): Actual count of seasonal homes with lake frontage existing on shoreline
Residential (Permanent): Actual count of permanent homes with lake frontage existing on shoreline
Agriculture & Silvaculture: Agricultural frontage presently cultivated, including orchards, vegetables, grain, hay, etc. existing on shoreline
Fish & Wildlife: Existing length of shoreline occupied by woodland, swampland, or wasteland having significant fish and wildlife habitat value
Recreation (Federal and State): Number of miles Federal and State parks exist on shoreline
Recreation (Local and Private): Number of miles Local and Private parks exist on shoreline
Undeveloped: Existing length of shoreline not yet developed

LAKE SUPERIOR	Total Length of Shoreline	Indst.	Comm.	Resid. (Seas.)	Resid. (Perm.)	Ag. & Silvct.	Fish & Wldlfe	Recr. (Fed./State)	Recr. (Local/Priv.)	Undev.	Miles of Existing Protective Structures
MICHIGAN											
Chippewa County - Lake Superior	58.8	---	2.6	4.3	1.0	45.2	2.0	2.0	0.1	1.6	1.7
Total Percentage for Chippewa County	(100%)	---	4.4	7.3	1.7	76.9	3.4	3.4	0.2	2.7	2.9
Luce County - Lake Superior	31.9	---	---	0.2	0.1	25.6	---	6.0	---	---	0.5
Total Percentage for Luce County	(100%)	---	---	0.6	0.3	80.3	---	18.8	---	---	1.6
Alger County - Lake Superior	113.8	0.4	1.9	2.6	13.4	70.3	0.5	20.1	4.6	---	0.36
Total Percentage for Alger County	(100%)	0.4	1.7	2.3	11.8	61.8	0.4	17.6	4.0	---	0.3
Marquette County - Lake Superior	75.4	5.3	0.4	12.7	2.5	42.8	3.2	3.6	4.9	---	5.40
Total Percentage for Marquette Cty.	(100%)	7.0	0.5	16.8	3.3	56.8	4.2	4.8	6.6	---	7.2
Baraga County - Lake Superior	75.3	1.6	1.8	5.5	3.6	46.2	11.3	2.6	0.7	2.0	2.40
Total Percentage for Baraga County	(100%)	2.1	2.4	7.3	4.7	61.4	15.0	3.5	0.9	2.7	3.2
Houghton County											
Lake Superior - Mainland	53.1	0.5	1.0	5.9	1.4	33.5	1.8	1.5	2.8	4.7	0.69
Keweenaw Waterway	98.3	6.4	1.1	6.3	7.0	0.7	9.7	0.1	4.3	62.7	9.75
Total Houghton County	151.40	6.9	2.1	12.2	8.4	34.2	11.5	1.6	7.1	67.4	10.44
Total Percentage for Houghton Cty.	(100%)	4.6	1.4	8.1	5.5	22.5	7.6	1.1	4.7	44.5	6.9
Keweenaw County - Lake Superior	94.4	0.3	1.0	4.5	0.5	77.7	1.0	1.2	0.7	7.5	8.60
Total Percentage for Keweenaw Cty.	(100%)	0.3	1.1	4.8	0.5	82.3	1.1	1.3	0.7	7.9	9.1
Ontonagon County - Lake Superior	49.5	0.2	0.7	1.8	0.5	24.9	---	9.6	0.7	11.1	0.71
Total Percentage for Ontonagon Cty.	(100%)	0.4	1.4	3.6	1.0	50.4	---	19.4	1.4	22.4	1.4
Gogebic County - Lake Superior	34.5	---	---	4.8	0.1	18.7	---	10.5	0.4	---	0.50
Total Percentage for Gogebic Cty.	(100%)	---	---	13.9	0.3	54.2	---	30.4	1.2	---	1.4
TOTAL MICHIGAN	685.00	14.70	10.50	48.60	30.10	385.60	29.50	57.20	19.20	89.60	30.61
TOTAL PERCENTAGE FOR MICHIGAN	(100%)	2.1	1.5	7.1	4.4	56.3	4.3	8.4	2.8	13.1	4.5

LAKE SUPERIOR (Continued)	Total Length of Shoreline	Indst.	Comm.	Resid. (Seas.)	Resid. (Perm.)	Ag. & Silvct.	Fish & Wldlfe	Recr. (Fed./ State)	Recr. (Local/ Priv.)	Undev.	Miles of Existing Protective Structures
WISCONSIN											
Iron County - Lake Superior	7.3	---	---	---	---	7.1	---	---	0.2	---	0.50
Total Percentage for Iron County	(100%)	---	---	---	---	97.5	---	---	2.5	---	6.9
Ashland County - Lake Superior	37.3	4.6	0.5	0.3	1.0	6.6	23.3	---	1.0	---	2.17
Total Percentage for Ashland Cty.	(100%)	12.3	1.3	0.8	2.7	17.7	62.5	---	2.7	---	5.8
Bayfield County - Lake Superior	87.8	0.5	2.2	9.5	11.0	47.8	7.5	0.1	0.9	8.3	5.21
Total Percentage for Bayfield Cty.	(100%)	0.6	2.5	10.8	12.5	54.4	8.5	0.1	1.1	9.5	5.9
Douglas County - Lake Superior	19.3	---	---	0.2	0.1	17.8	0.2	---	0.3	0.7	0.04
Total Percentage for Douglas Cty.	(100%)	---	---	1.0	0.5	92.3	1.0	---	1.6	3.6	0.2
TOTAL WISCONSIN	151.70	5.1	2.7	10.0	12.1	79.3	31.0	0.1	2.4	9.0	7.92
TOTAL PERCENTAGE FOR WISCONSIN	(100%)	3.4	1.8	6.6	8.0	52.3	20.4	0.1	1.6	5.8	5.2
MINNESOTA											
Cook County - Lake Superior	91.5	---	6.7	8.1	9.0	22.2	---	44.6	---	0.9	1.06
Total Percentage for Cook County	(100%)	---	7.3	8.9	9.8	23.4	---	48.7	---	1.0	1.2
Lake County - Lake Superior	49.7	---	5.4	9.6	7.0	22.7	---	5.0	---	---	1.11
Total Percentage for Lake County	(100%)	---	10.9	18.4	14.4	45.9	---	10.4	---	---	2.2
St. Louis County											
Lake Superior - Mainland	32.4	---	2.8	1.6	5.7	5.4	0.5	12.2	4.0	0.2	11.10
Duluth-Superior Harbor	99.6	6.9	23.2	0.1	3.1	---	---	3.0	2.8	60.5	9.51
Total St. Louis County	132.0	6.9	26.0	1.7	8.8	5.4	0.5	15.2	6.8	60.7	20.61
Total Percentage for St. Louis Cty.	(100%)	5.2	19.7	1.3	6.7	4.1	0.3	11.5	5.2	46.0	15.6
TOTAL MINNESOTA	273.2	6.9	38.1	19.4	24.8	50.3	0.5	64.8	6.8	61.6	22.78
TOTAL PERCENTAGE FOR MINNESOTA	(100%)	2.5	13.9	7.1	9.1	18.4	0.3	23.7	2.5	22.5	8.3

LAKE SUPERIOR (Continued)	Total Length of Shoreline	Indst.	Comm.	Resid. (Seas.)	Resid. (Perm.)	Ag. & Silvct.	Fish & Wldlfe	Recr. (Fed./ State)	Recr. (Loca./ Priv.)	Undev.	Miles of Existing Protective Structures
Subtotal											
Keweenaw Waterway Shoreline	98.3	6.4	1.1	6.3	7.0	0.7	9.7	0.1	4.3	62.7	9.75
Subtotal Percentage for KWS	(100%)	6.5	1.1	6.4	7.1	0.7	9.9	0.1	4.4	63.8	9.9
Duluth-Superior Harbor Shoreline	99.6	6.9	23.2	0.1	3.1	---	---	3.0	2.8	60.5	9.51
Subtotal Percentage for DSHS	(100%)	6.9	23.3	0.1	3.1	---	---	3.0	2.9	60.7	9.6
Lake Superior Shoreline	912.00	13.40	27.00	71.60	56.9	514.5	51.3	119.0	21.3	37.0	42.05
Subtotal Percentage for LSS	(100%)	1.5	3.0	7.9	6.2	56.4	5.6	13.0	2.3	4.1	4.6
GRAND TOTAL: LAKE SUPERIOR BASIN SHORELINE (STUDY AREA)	1109.9	26.7	51.3	78.0	67.0	515.2	61.0	122.1	28.4	160.2	61.31
	(100%)	2.4	4.6	7.0	6.0	46.4	5.5	11.0	2.7	14.4	5.6

TL:tl